GA1.13:RCED-89-49

United States General Accounting Office

Report to the Chairman, Committee on Energy and Commerce, House of Representatives

COMPLETED
69

STRATOSPHERIC OZONE

EPA's Safety Assessment of Substitutes for Ozone-Depleting Chemicals

GAO

United States
General Accounting Office
Washington, D.C. 20548

Resources, Community, and
Economic Development Division

B-232917

February 13, 1989

The Honorable John D. Dingell
Chairman, Committee on Energy and Commerce
House of Representatives

Dear Mr. Chairman:

As you requested, this report describes and evaluates the efforts being made by the Environmental Protection Agency (EPA) to assess the safety of chemicals used as substitutes for chlorofluorocarbons (CFCs) and halons that harm the stratospheric ozone layer. This report also describes the scope and status of projects sponsored by EPA that are designed to reduce the use of CFCs and halons.

As arranged with your office, unless you publicly release its contents earlier, we plan no further distribution of this report until 30 days after the date of this letter. At that time, copies of the report will be sent to appropriate congressional committees; the Administrator, Environmental Protection Agency; and the Director, Office of Management and Budget. We will also make the report available to other interested parties.

This work was performed under the general direction of Hugh J. Wessinger, Senior Associate Director. Other major contributors are listed in appendix III.

Sincerely yours,

J. Dexter Peach

J. Dexter Peach
Assistant Comptroller General

Executive Summary

Purpose

Emissions from chemicals known as chlorofluorocarbons (CFCs) and halons are depleting stratospheric ozone, which shields the earth from the sun's harmful ultraviolet radiation. The Environmental Protection Agency (EPA) estimates that for people born in the United States by the year 2075, unabated depletion could lead to 178 million cases of skin cancer, along with other health and environmental problems. The chemical industry and governments worldwide are seeking alternatives for CFCs and halons used in many commercial applications, such as air conditioning, refrigeration, insulation, electronics manufacturing, and fire fighting.

At the request of the Chairman of the House Committee on Energy and Commerce, GAO reviewed EPA's efforts to (1) assess the safety of chemical substitutes for ozone-depleting CFCs and halons and (2) investigate techniques for CFC and halon conservation and recycling, along with other measures designed to reduce industry's dependence on ozone-depleting chemicals.

Background

Sections 150-159 of the Clean Air Act, as amended, direct EPA to undertake research on the causes and effects of stratospheric ozone depletion and on safe substitutes for and alternatives to ozone-depleting chemicals. In 1987, the United States, along with other countries, signed an international agreement—the Montreal Protocol—to protect stratospheric ozone. The protocol was ratified internationally in late 1988 and entered into force on January 1, 1989. It sets forth a 10-year time frame for signatory countries to cut their CFC production levels by as much as 50 percent of 1986 levels. Halon production is to be frozen in 1992 at 1986 levels. In August 1988, EPA issued regulations to implement the terms of the protocol domestically.

Chemical producers are currently attempting to develop chemical substitutes for ozone-depleting CFCs and halons that are economically viable, technically effective, and safe for human health and the environment. Under provisions of the Toxic Substances Control Act (TSCA), EPA is responsible for ensuring that chemical substitutes present no unreasonable risks to public health and the environment. EPA is also assisting industry by sponsoring activities related to CFC and halon conservation and recycling and developing innovative industrial processes that do not use CFCs.

Results in Brief

EPA aims to ensure that CFC and halon substitutes present no unreasonable risks to health and the environment. Its safety assessment approach relies mainly on special efforts by the EPA staff to analyze available toxicity data on likely substitutes and gain the voluntary cooperation of producers to provide EPA with unpublished information on their current testing. EPA's approach, however, does not include the use of TSCA authority to require producers to submit their health and safety studies on substitutes, nor does it require producers to notify EPA of intended significant new uses of existing chemicals as substitutes for CFCs and halons before commercialization in order to give EPA an opportunity to review and, if necessary, control such uses. Producers currently have the option of commercializing most of the currently identified CFC substitutes at any time without an EPA safety review.

In keeping with its legislative mandate under the Clean Air Act, EPA has several projects underway related to CFC and halon conservation and recycling, as well as non-CFC manufacturing processes, that may help industry reduce future CFC and halon use and emissions. However, since these projects concern the initial stages of the conservation process, the extent to which they may prove successful is still uncertain.

Principal Findings

Safety of Substitutes for CFCs and Halons

The impending regulation of CFCs and halons has prompted chemical producers to accelerate their work on developing safe chemical substitutes for these chemicals. An important part of the development process involves toxicological testing. Although the producers themselves are testing potential substitutes, EPA has statutory responsibilities under TSCA to identify, assess, and control risks to human health and the environment from chemical substances used in commerce, including CFC and halon substitutes.

By November 1988, EPA had developed an approach for assessing the safety of substitutes. New chemical substitutes will go through EPA's standard new chemical review process. For other chemicals, including the leading alternative fluorocarbons, EPA will urge producers to provide, on a voluntary basis, information on their ongoing testing and test rationale. Following an evaluation of this information, as well as other available toxicity data, EPA will advise the producers of its concerns and needs regarding the testing of substitutes. The plan also calls for EPA to

evaluate the role of TSCA regulatory approaches for ensuring the development of appropriate test data and addressing potential unreasonable risks to health and the environment.

EPA's assessment approach does not, at present, include the use of its statutory authority under section 8(d) of TSCA to require producers to submit their unpublished health and safety studies on the potential substitute chemicals. EPA believes that such information can be obtained more quickly through voluntary agreements with the producers. However, EPA's previous attempt to obtain testing data on potential substitutes in a voluntary manner resulted in incomplete data.

EPA's approach also does not, at present, include the use of its TSCA section 5(a)(2) authority to require that intended significant new uses of existing chemicals as CFC and halon substitutes be reported to EPA so that it can assess their safety and, if necessary, quickly control new uses that pose an unreasonable risk to human health and the environment. Currently, most of the potential substitutes identified so far can be produced by anyone, in any amount, and for any use without prior notification to EPA or an EPA safety review.

Growing concern over the ozone depletion problem is creating tension between the need to move away from the use of ozone-depleting chemicals quickly and the need to establish the safety of chemical substitutes before commercializing them. Under its current assessment approach, EPA intends to deal with the issue of integrating ozone depletion concerns and traditional toxicity concerns on a case-by-case basis as it assesses the safety of individual substitutes.

CFC and Halon Conservation Projects

EPA is currently sponsoring nine projects for recovering and recycling CFCs and halons, as well as using industrial processes that do not depend on these chemicals. The projects, which will cost EPA $441,100, are appropriately focused on major uses of ozone-depleting chemicals. For example, one project aims at encouraging the recovery and recycling of automobile air-conditioning fluids during servicing by helping industry to develop purity standards for recycled CFCs. In another project, EPA is working with the Department of Defense (DOD) to identify opportunities to revise military specifications for electronics manufacturing in order to allow the use of effective non-CFC solvents. EPA is also working with DOD and private industry on ways to conserve halons used during fire-

fighting training and systems testing. Other projects include technologies to reduce the use of CFCs in home refrigeration and in the manufacturing of rigid foam insulation. Since these and the other projects concern the initial steps in the conservation process, it is too soon to evaluate how successful they may be in helping to reduce the use of CFCs and halons.

Recommendations

GAO recognizes the need to move away from the use of ozone-depleting chemicals. Like EPA, GAO believes that chemicals used as CFC and halon substitutes should not pose unreasonable risks or create health or environmental problems. To help ensure that EPA obtains health and safety studies on substitute chemicals and is informed about the new uses of existing chemicals as substitutes, GAO recommends that the EPA Administrator use the provisions of the Toxic Substances Control Act to (1) require producers to provide EPA with their unpublished health and safety studies on chemical substitutes for CFCs and halons and (2) require producers to notify EPA before existing chemicals are put to significant new uses as CFC and halon substitutes so that EPA can review the safety of these uses and, if necessary, quickly control them.

Agency Comments

GAO discussed the matters in this report with EPA officials and incorporated their comments where appropriate. However, as requested by the Chairman, GAO did not obtain official agency comments on the report's conclusions and recommendations.

Contents

Executive Summary		2
Chapter 1 Introduction and Background		10
	Extent of Stratospheric Ozone Depletion	10
	Potential Effects of Ozone Depletion	11
	CFC and Halon Use and Emissions	12
	International and Domestic Efforts to Protect the Stratosphere	13
	The Montreal Protocol and EPA Regulations	16
	More Stringent Cutbacks Are Possible	17
	The Need for CFC Substitutes	18
	Objectives, Scope, and Methodology	20
Chapter 2 EPA Should Rely More on TSCA Authority in Assessing the Safety of CFC and Halon Substitutes		21
	EPA's Role Regarding Safe Substitutes	22
	Elements of a Toxicity Evaluation	22
	EPA's Reports on the Development of Chemical Substitutes for CFCs	24
	Chemical Producers' Testing of Alternative Fluorocarbons	27
	Chemical Substitutes Other Than Alternative Fluorocarbons	28
	EPA's Approach to Assessing CFC and Halon Substitute Safety	30
	EPA Should Rely More on TSCA Authorities in Assessing Substitute Safety	37
	EPA's Work on Environmental Effects of Substitutes Is Focused on Regulatory Issues	41
	Conclusions	43
	Recommendations to the EPA Administrator	45
Chapter 3 EPA's Projects Strive for Reductions in Major Uses of CFCs and Halons		46
	EPA Has Authority to Conduct the Projects	46
	EPA's Project Selection Criteria	47
	Project on Evaluation of Refrigerant From Mobile Air Conditioners	47
	Project on Cell Size in Rigid Foam Insulation	49
	Refrigeration and Air Conditioning Projects	50
	Project on Military Specifications for CFC Solvent Use	54
	Halon Fire Extinguisher Projects	56
	Conclusions	59

Appendixes

Appendix I: Key Provisions of the Montreal Protocol 60
Appendix II: Summary of EPA Memorandums Leading to the November 2, 1988, Assessment Approach 63
Appendix III: Major Contributors to This Report 66

Tables

Table 1.1: Potential Additional Skin Cancer and Cataract Cases in the United States for People Born by the Year 2075 12
Table 1.2: Uses of CFCs and Halons Regulated by the Montreal Protocol 16
Table 2.1: Other Chemicals Identified by EPA as Technically Feasible CFC Substitutes in Certain Applications 29
Table 3.1: EPA Projects on CFC and Halon Conservation 47

Figures

Figure 1.1: How Uses of CFCs Contribute to Ozone Depletion (1985 Data. Percentages Weighted to Reflect the Ozone-Depletion Potential of CFCs Used for Each Purpose.) 14
Figure 2.1: Commercial Development Process for New Chemicals 23

Abbreviations

AFEAS	Alternative Fluorocarbon Environmental Acceptability Study
CFC	chlorofluorocarbon
DME	dimethyl ether
DOD	Department of Defense
DOE	Department of Energy
EPA	Environmental Protection Agency
FC	fluorocarbon
FDA	Food and Drug Administration
GAO	General Accounting Office
MAC	mobile air conditioner
MIT	Massachusetts Institute of Technology
NASA	National Aeronautics and Space Administration
OAR	Office of Air and Radiation
OSHA	Occupational Safety and Health Administration
OTS	Office of Toxic Substances
PAFT	Program for Alternative Fluorocarbon Toxicity Testing
PMN	premanufacture notification
RCRA	Resource Conservation and Recovery Act
SNUR	significant new use rule
TSCA	Toxic Substances Control Act
UNEP	United Nations Environment Programme
UV-B	ultraviolet-B
VOC	volatile organic compound

BLANK PAGE

Chapter 1

Introduction and Background

Ozone (triatomic oxygen) is a critical component of the earth's stratosphere[1] that absorbs much of the sun's destructive ultraviolet radiation. If the amount of stratospheric ozone were to diminish significantly, the higher levels of ultraviolet radiation reaching the earth's surface would cause serious harm to human health and the environment.[2]

It is now scientifically accepted that stratospheric ozone molecules are being depleted globally by commonly used industrial chemicals known as chlorofluorocarbons (CFCs) and halons. The United States and numerous other countries that manufacture and use these chemicals have agreed to control CFC and halon production in an effort to preserve the ozone. This report discusses the U.S. Environmental Protection Agency's (EPA) efforts to (1) develop an approach for assessing the safety of chemical substitutes for CFCs and halons and (2) conduct research projects on conservation, recycling, and alternative technologies that would reduce the need for CFCs and halons.

Extent of Stratospheric Ozone Depletion

Stratospheric ozone molecules are continually being created and destroyed by natural atmospheric processes, but at similar rates, so that the overall level of ozone remains relatively constant. In 1974, scientists at the University of California calculated that chlorine in CFC emissions rising into the stratosphere could upset the natural ozone balance by reacting with and breaking down ozone molecules.

Actual stratospheric ozone depletion, however, was not reported until 11 years later, when British scientists published an article describing a rapid and unexpected thinning of the ozone layer over Antarctica in the springtime. A subsequent review of archived satellite data showed that a temporary "ozone hole" (as the popular press called it) had been occurring each spring in the Antarctic since 1979. (During the Antarctic summer, the ozone level builds up again.) An international effort, which included scientists from the National Aeronautics and Space Administration (NASA) and the National Science Foundation, was organized in 1986-87 to further investigate the "hole" and try to determine its cause.

[1]The stratosphere is a layer of the atmosphere that ranges from approximately 10 to 30 miles above the earth's surface.

[2]Ozone is also present in the lower atmosphere, where it is a primary constituent of smog. It is created by chemical reactions involving sunlight and gases emitted into the atmosphere by motor vehicles and industry. Ozone in the lower atmosphere is a pollutant that can harm human health and the environment.

In October 1986, NASA, the National Oceanic and Atmospheric Administration, the Federal Aviation Administration, the United Nations Environment Programme, and the World Meteorological Organization formed an Ozone Trends Panel to review global data on ozone levels. In its March 1988 report, the panel concluded that the observed changes in ozone may be due wholly, or in part, to the increased abundance of trace gases, primarily CFCs. According to the panel, decreases in ozone have occurred outside the Antarctic as well. The report stated that data from 1969 to 1986 for northern middle latitudes (30 to 64 degrees) show average annual decreases in stratospheric ozone ranging from 1.7 to 3.0 percent—with decreases as large as 6.2 percent during winter months. These latitudes include most of North America, Europe, the Soviet Union, and China.

Potential Effects of Ozone Depletion

Continued ozone depletion may have grave consequences for human health and the environment. A 1987 EPA risk assessment[3] drew together scientific evidence assessing the potential effects of ultraviolet-B radiation (UV-B).[4] An increase in UV-B would increase occurrences of skin cancer and cataracts and would possibly suppress the human immune system. Another EPA document projected that stratospheric ozone will be depleted by more than 50 percent by the year 2075 if no controls were placed on CFCs and halons and their production continued to grow through 2050 at 1986 rates.[5] According to EPA, the resulting increase in UV-B would cause millions of additional cases of skin cancer and cataracts in the United States among people born by the year 2075, as shown in table 1.1.

[3]Assessing the Risks of Trace Gases That Can Modify the Stratosphere. U.S. Environmental Protection Agency, December 1987.

[4]The three types of ultraviolet radiation are classified according to their wavelength. UV-C, the most harmful, does not reach the earth's surface. UV-B, which is somewhat less harmful, is absorbed partially by stratospheric ozone. UV-A, the least harmful, reaches the earth with little obstruction.

[5]Regulatory Impact Analysis: Protection of Stratospheric Ozone. U.S. Environmental Protection Agency, August 1, 1988.

Table 1.1: Potential Additional Skin Cancer and Cataract Cases in the United States for People Born by the Year 2075

Figures in thousands

Scenario	Ozone depletion by 2075 (percent)	Non-melanoma cancer[a] (whites only) Cases	Non-melanoma cancer[a] (whites only) Deaths	Melanoma cancer[a] (whites only) Cases	Melanoma cancer[a] (whites only) Deaths	Cataract cases
No controls	50[b]	177,998	3,529	893	211	20
CFC 50% cut & halon freeze	1.9	5,104	81	46	11	876

[a]EPA states that non-white people are less likely to be affected by skin cancer.

[b]EPA projects that depletion will be at least 50 percent but cannot estimate beyond that level with certainty.

Source: EPA Regulatory Impact Analysis: Protection of Stratospheric Ozone, August 1, 1988.

Even if emissions of CFCs and halons were halted immediately, some level of ozone depletion would still occur as a result of CFC and halon emissions that have occurred since their introduction into commercial use. The chairman of the Ozone Trends Panel said that even if CFC production were reduced immediately by 90 percent, the ozone hole over Antarctica would last 50-60 years. That is because these substances have atmospheric lifetimes that last many decades,[6] during which time they continue to react with and destroy ozone molecules.

EPA's risk assessment also indicated that increases in UV-B may reduce crop yields and alter terrestrial and aquatic ecosystems, although it concedes that these effects are harder to quantify than the skin cancers. The risk assessment also points out that CFCs in the lower atmosphere directly contribute to global warming (the "greenhouse effect"). Increased global warming may bring about major effects on the earth, such as higher average sea levels and changes in precipitation, humidity, and wind patterns.

CFC and Halon Use and Emissions

CFCs and halons, the chief agents in stratospheric ozone depletion, have many common applications. CFCs are used as coolants in refrigerators and freezers and in home, office, and automobile air conditioners; as propellants in aerosols; as blowing agents for plastic foam products and insulation; as cleaning agents for metals and electronic equipment; and

[6]The estimated atmospheric lifetimes of the five CFCs and three halons covered by EPA regulations described below, as reported in EPA's Regulatory Impact Analysis, are: CFC-11, 64 years; CFC-12, 108 years; CFC-113, 88 years; CFC-114, 185 years; CFC-115, 380 years; Halon 1211, 25 years; Halon 1301, 110 years; and Halon 2402, unknown.

as sterilants for medical instruments. Figure 1.1 shows the relative percentages of each major use.[7] Representatives of the CFC industry have estimated that CFCs are used by 5,000 businesses to produce $28 billion worth of goods and services in the United States each year and that the value of installed products relying on CFCs is more than $135 billion. Halons are used primarily as fire extinguishers in ships, planes, and military vehicles, as well as computer facilities, telephone switching centers, libraries, and other places having materials that would be damaged by water or foam fire extinguishers.

CFCs and halons are emitted into the atmosphere in several ways. For example, CFCs used in foam blowing are emitted during the blowing process, while the foam is being cured, over the lifetime of the product, and when the product is destroyed. CFCs used as solvents evaporate into the atmosphere during the cleaning process. Refrigerant CFCs are emitted through faulty connections during use, during the testing of new or malfunctioning systems, or when the system is scrapped. Halons are emitted to fight fires and train fire fighters and, to a greater degree, to test extinguisher systems.

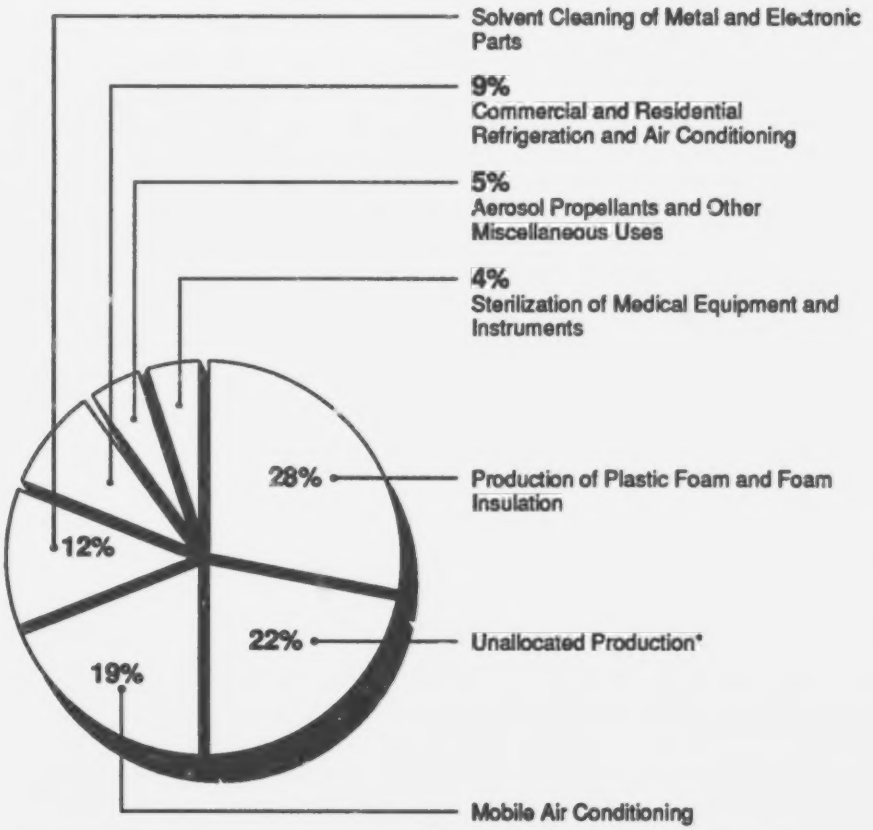
International and Domestic Efforts to Protect the Stratosphere

The United States led the world in regulating CFCs during the late 1970s after scientific research in 1974 showed that chlorine would deplete stratospheric ozone. The Congress included several sections in the 1977 amendments to the Clean Air Act that direct the EPA Administrator to assess the state of stratospheric ozone and take actions to protect it, if necessary. Specifically, sections 150-159 of the act direct the Administrator to study the effect of all substances on stratospheric ozone, search for ways to reduce the emission of substances that harm the ozone, coordinate ozone research with other federal agencies, and report to the Congress on the progress of all federal research and regulatory actions related to ozone protection.

In 1977 and 1978, the Food and Drug Administration (FDA), and the Consumer Product Safety Commission required manufacturers using CFCs as aerosol propellants (the dominant use of CFCs in the 1970s) to place labels on their products warning of their impact on stratospheric ozone. In 1978, EPA and FDA instituted a ban on CFCs in nearly all domestic and imported aerosols. These actions, as well as economic circumstances and

[7]The percentages are weighted to reflect the varying ozone depletion potential of CFCs. CFC-11, -12, and -114 have the same ozone-depletion potential. CFC-113 and -115 have 80 and 60 percent, respectively, of the depletion potential of the others.

Figure 1.1: How Uses of CFCs Contribute to Ozone Depletion (1985 Data. Percentages Weighted to Reflect the Ozone-Depletion Potential of CFCs Used for Each Purpose.)



*Unallocated Production: This fraction represents the difference between total production and estimated usage in the categories shown. Factors in the difference include overseas trade, unreported military uses, and inexact accounting of sales.

Source: EPA.

public concern, quickly led to a 95-percent reduction in aerosol-related CFC production as manufacturers turned to alternative propellants that do not deplete the ozone. Several other nations, primarily in Europe, joined the United States and enacted partial restrictions on the use of CFCs in the late 1970s and early 1980s.[8]

[8]The countries that enacted some form of restrictions are Belgium, Norway, Sweden, Portugal, Canada, and Australia.

In 1980, EPA issued an Advance Notice of Proposed Rulemaking (45 Fed. Reg. 66726) that raised the prospect of placing a freeze on total U.S. production of CFCs. EPA ultimately delayed the pursuit of this proposed rulemaking, however, citing scientific uncertainty about the dynamics of ozone depletion and the actual impact of CFCs on stratospheric ozone. Other events also diminished the attention paid to ozone depletion, including the restrictions on aerosols in the United States and abroad (which was widely interpreted by the U.S. public as the solution to the ozone-depletion problem) and a worldwide recession that reduced the growth of CFC production and use.

In the United States, use of the two most important ozone depleters (CFC-11 and CFC-12) began to grow in 1982 after 6 years of decline. Use of CFC-113 showed steady growth through the late 1970s and early 1980s. Concerned that EPA had not acted upon the proposed rulemaking, the Natural Resources Defense Council (an environmental protection advocacy organization) sued EPA in 1984 to compel the Agency to promulgate stratospheric ozone-protecting regulations under the authority of the Clean Air Act. The lawsuit was settled with an agreement whereby EPA was required to propose CFC regulations by December 1, 1987, or state its reasons against the necessity of regulations.

International concern over ozone depletion also mounted during the early 1980s. In 1981, the United Nations Environment Programme (UNEP) began negotiations on a framework for worldwide CFC reductions. These negotiations led to the adoption of the Vienna Convention for Protection of the Ozone Layer in 1985, which established a framework for further negotiations on reductions, required participating countries (signatories) to submit CFC production and consumption data, and recommended more research on ozone depletion.

Following the Vienna Convention, and in response to a better understanding of the link between CFCs and ozone depletion, EPA published a Stratospheric Ozone Protection Plan (51 Fed. Reg. 1257) on January 10, 1986. EPA's plan supported the need to carry on international negotiations, workshops, and research on ozone depletion. It also committed EPA to prepare a risk assessment on stratospheric ozone depletion that would review the scientific understanding of all aspects of this issue and serve as the basis for making future EPA decisions.

The Montreal Protocol and EPA Regulations

UNEP held further international negotiations on stratospheric ozone regulation during 1986-87, resulting in development and signing of the September 1987 "Montreal Protocol on Substances that Deplete the Ozone Layer." In late 1988, the protocol was ratified internationally by the requisite countries (at least 11 countries that account for two-thirds of the world's 1986 CFC consumption), and entered into force on January 1, 1989. The protocol requires signatories to freeze their production and consumption of five major CFCs at 1986 levels, followed by phased-in reductions of up to 50 percent by 1999. And beginning in 1992, the protocol freezes the signatories' production and consumption of three halons at 1986 levels. (Table 1.2 shows the regulated chemicals and their major uses.) Each signatory country is free to develop its own method of achieving these freezes and reductions. (The protocol also contains a number of trade restrictions regarding CFCs, halons, and related products, as well as 10-year waivers from the restrictions for developing countries that use less than 0.3 kilograms per capita. The protocol's key provisions are summarized in app. I.)

Table 1.2: Uses of CFCs and Halons Regulated by the Montreal Protocol

	CFC-11	CFC-12	CFC-113	CFC-114	CFC-115	Halon 1211	Halon 1301	Halon 2402
Aerosol	X	X						
Foam blowing	X	X		X				
Air conditioning and refrigeration	X	X		X	X			
Mobile air conditioning		X						
Solvent			X					
Sterilization		X						
Fire extinguishing						X	X	X

Note: Halon 2402 has only minor uses in the United States.

Source: EPA.

On August 12, 1988, EPA published in the Federal Register a final rule, entitled "Protection of Stratospheric Ozone" (53 Fed. Reg. 30566), designed to implement the Montreal Protocol and also satisfy the court agreement reached with the Natural Resources Defense Council to decide on whether or not to regulate CFCs. The final rule became effective when the protocol entered into force on January 1, 1989.

The rule calls for a freeze and reduction schedule for CFC and halon production and consumption that is identical to the schedule required by

the protocol. The rule adopts a regulatory approach that allocates production quotas to current CFC and halon producers based on their share of 1986 U.S. production.[9] CFC and halon importers will also be given an allocation, based on the quantity they imported in 1986, that will allow them to continue to purchase the chemicals from abroad. CFC and halon users will then be free to compete with each other for the available supply of the chemicals sold by the current producers and importers.

More Stringent Cutbacks Are Possible

Even before the Montreal Protocol was ratified, concerns were raised by Members of Congress, scientists, environmental advocacy groups, and even EPA. The concern was, and is, that the protocol's restrictions do not go far enough to protect stratospheric ozone. Critics of the protocol maintain that its 10-year timetable to cut CFC production in half is too little, too late. They point out that even if CFC production were to be halted immediately, the CFCs already in the atmosphere would continue to deplete ozone for many decades. A February 1988 analysis of the protocol by the Office of Technology Assessment reported that worldwide use of CFC-11 and -12 (for which the best global data are available) would be reduced by 1999 only by an estimated range of 15 to 35 percent, even if all the world's nations join the protocol.[10] (This estimate assumes that no far-reaching technological changes will occur that might render CFCs obsolete.) And, on October 5, 1988, the Natural Resources Defense Council sued EPA for what it charges is the inadequacy of the Agency's final CFC regulations. The Council is calling for a complete phase-out of CFCs.

CFC and halon producers have generally supported the protocol and its phase-down schedule. Two producers have, in fact, announced their intention to go beyond it and halt production of ozone-depleting CFCs altogether. In a March 24, 1988, letter to EPA shortly after the Ozone Trends Report was released, Du Pont (the world's largest CFC producer) declared that it will completely phase out its production of these CFCs as soon as substitutes become available. Du Pont made the year 2000 its target date for ceasing production. The other producer that plans to halt

[9]Along with the final rule, EPA issued an Advance Notice of Proposed Rulemaking (53 Fed. Reg. 30604) seeking comments on the appropriateness of supplementing the allocated quotas with regulatory fees or replacing the allocation system with an auction system. EPA also sought comments on the use of industry-specific control requirements. These comments have been received and EPA may or may not take further action.

[10]An Analysis of the Montreal Protocol on Substances that Deplete the Ozone Layer. Oceans and Environment Program, Office of Technology Assessment, U.S. Congress, December 10, 1987 (revised February 1, 1988).

production is Pennwalt, though it has offered no time frame. A third producer, ICI, has called for an urgent review of the protocol and consideration of a phaseout of certain ozone-depleting CFCs.

The protocol itself provides for the cutback schedule to be changed to reflect new scientific evidence. It requires that currently agreed-upon production reductions be reevaluated during 1990 (and every 4 years thereafter) in light of any research developments in stratospheric ozone and CFCs. Following the Ozone Trends Panel's findings indicating statistically significant global depletion, Members of Congress and EPA's Administrator urged that UNEP undertake its reevaluation sooner. Under a revised schedule, UNEP will issue a report in the summer of 1989, a year earlier than planned. The report's findings could lead to a reconsideration of the protocol's schedule for reductions. On September 26, 1988, the EPA Administrator urged all nations to ratify the protocol and then move toward a complete phaseout of ozone-depleting CFCs and halons.

The Need for CFC Substitutes

Clearly, the need for CFC and halon substitutes is present and growing. Even the initial phase of the protocol calling for a production "freeze" at 1986 levels will result in CFC cutbacks because current production levels are already several percentage points higher than 1986 levels.[11]

The effect of CFC regulations on industry depends not only on the pace of CFC reductions, but also on the speed with which substitutes can be developed and commercialized. Some users have already found the means to move away from the regulated CFCs. For example, the Foodservice & Packaging Institute, Inc., recently announced that a significant percentage of its members have pledged to discontinue using, by December 31, 1988, CFC-11 and -12 to produce disposable foam plastic products such as cups, plates, meat trays, egg cartons, and fast-food containers. This pledge is possible because HCFC-22, which has only 5 percent of the capacity to deplete the ozone as CFC-11 and -12, is a commercially available substitute. For other industrial applications, however, substitute chemicals or products are either not yet available or not as effective. For example, there are no fire extinguishers that have the useful properties of halon, and commercially available alternative insulating materials are not as energy efficient as CFC-blown rigid foam.

[11]The exact percentage, based on reports by producers to EPA, is protected as confidential business information. The International Trade Commission, however, reported that U.S. production of CFC-11 and CFC-12 grew from 1986 to 1987 by 11.0 and 14.3 percent, respectively.

Several producers of CFCs have announced stepped-up research efforts to develop chemical substitutes. Du Pont announced in July and September 1988 that it plans commercial production in Michigan and Texas of three alternatives to regulated CFCs. The alternatives are HFC-134a, HCFC-141b, and HCFC-142b, which have applications in refrigeration, air conditioning, and foam blowing. Du Pont also has a pilot plant in New Jersey for producing developmental quantities of HCFC-123. Du Pont reports that it will spend more than $30 million in 1988 on CFC alternatives research and production. ICI, headquartered in Great Britain, is spending approximately $83 million (50 million pounds sterling) in search of benign CFC substitutes and has two pilot plants producing test quantities of alternative chemicals. And, in November 1988, ICI announced plans to spend about $50 million on a plant in the United States for the commercial production of HCFC-134a by 1992. Allied Signal in the United States has reported that it will spend over $250 million on CFC research over the next 10 years. In March 1988, Allied-Signal joined with Atochem, Europe's largest CFC producer, in an effort to develop CFC substitutes. Each firm has pilot plants and plans to make the potential substitutes HCFC-123, HCFC-141b, and HFC-134a available to end-users for testing and evaluation by the end of 1988.

But even with increased research, substitutes may be several years away from commercialization, as discussed in chapter 2. Producers must not only identify and synthesize potential substitutes, but also subject them to tests to determine their performance capabilities in the particular applications for which they may be used. Most importantly, producers are putting substitutes through lengthy toxicological testing to assess their effects on human health and the environment. New production facilities must then be designed and constructed, increasing the time before substitutes can be provided in commercial quantities. In its September 1988 announcement regarding the commercial production of HFC-134a, Du Pont claimed that the substitute would be available for sale by the early 1990s. ICI announced in September that it aims to be the first chemical company in the world to make CFC alternatives available commercially but that safety and toxicity testing will delay introduction for at least 5 years.

Because chemical substitutes may not be available for several years, industry and government are looking for ways in which CFCs and halons can be conserved and recycled, or for products that can replace CFC-based items. EPA is co-sponsoring, with a variety of organizations, several projects that it hopes will contribute to reductions in use and emissions. These are discussed in chapter 3.

Objectives, Scope, and Methodology

The Chairman of the House Committee on Energy and Commerce requested that we investigate EPA's efforts in developing international and domestic regulation of ozone-depleting chemicals. As agreed with the Chairman's office, we reviewed EPA's efforts to assess the safety of chemical substitutes for ozone-depleting CFCs and halons. We also assessed the status of EPA-sponsored research on methods to reduce CFC and halon use and emissions.

We performed our work between January and December 1988 at EPA headquarters in Washington, D.C., and EPA's Office of Air Quality Planning and Standards in Durham, N.C. Our review focused on two EPA offices: the Office of Air and Radiation, the program office that developed and will implement the CFC regulations, and the Office of Toxic Substances, which is responsible for regulating chemicals used in commerce.

We reviewed each office's activities regarding the safety of substitute chemicals and steps being taken to reduce the use of ozone-depleting chemicals. We reviewed program files and confidential business information regarding production levels and substitutes research submitted to EPA by domestic producers and importers of CFCs and halons. We interviewed EPA officials, representatives of industries that produce and use CFCs and halons, and representatives of environmental protection advocacy organizations. We attended public hearings on ozone depletion and reviewed the large number of comments submitted to EPA regarding its proposed CFC and halon regulations. We reviewed grants awarded by EPA to contractors for work related to the development of substitute chemicals and conservation technologies. And we spoke with officials of the Departments of Energy and Defense about cooperative agreements with EPA for research and development projects. Our review and analysis reflects EPA's work up until early December 1988.

We discussed the information provided in this report with EPA officials and have included their comments where appropriate. However, as requested by the Chairman's office, we did not obtain official agency comments.

We performed our review in accordance with generally accepted government auditing standards.

EPA Should Rely More on TSCA Authority in Assessing the Safety of CFC and Halon Substitutes

In late 1987, shortly after the Montreal Protocol was signed and prior to its ratification internationally in late 1988, EPA began to consider what actions it should take to ensure that chemical substitutes for CFCs and halons do not create health or environmental problems of their own. By early November 1988, EPA developed a general approach for assessing the safety of the potential chemical substitutes. EPA intends to examine existing literature and toxicity data on such chemicals, identify testing that should be done to assess their health and environmental risks, and advise chemical producers of EPA's information needs. Under this approach, EPA plans to strongly urge the producers to provide voluntarily their views on assessment issues, summarize their ongoing testing and test plans, and describe their testing rationale.

EPA's assessment approach includes the use of TSCA section 5 authority to review and (if necessary) control new chemical substitutes. However, it does not include the use of other data-gathering and control authorities that are particularly relevant to its review of existing chemicals that may be used as CFC and halon substitutes. Specifically, EPA does not at present plan to use TSCA section 8(d) authority to require producers to provide EPA with their health and safety studies on potential substitutes. EPA staff maintain that they can obtain the health and safety information needed for their assessment more quickly through voluntary cooperation with the producers than through the formal TSCA rulemaking process. However, a previous EPA request to producers to provide testing information on potential CFC substitutes on a voluntary basis resulted in incomplete data submissions.

EPA's assessment approach also does not at present include the use of TSCA section 5(a)(2) authority to (1) require producers to notify EPA in advance of significant new uses of existing chemicals intended as CFC and halon substitutes and (2) enable EPA to review the safety of these new uses and quickly control those that pose a risk to human health and the environment. Currently, most of the potential chemical substitutes identified so far can be produced by anyone, in any amount, and for any use without prior notification to EPA or an EPA safety review.

EPA's approach does not specify how traditional toxicity concerns are to be integrated with concerns about continued stratospheric ozone depletion. EPA officials told us that they will deal with this issue on a case-by-case basis when assessing individual substitutes. Although EPA did not specify time frames for its safety assessment activities, some review work has begun.

EPA's Role Regarding Safe Substitutes

Article 9 of the Montreal Protocol calls upon participating parties to cooperate in research, development, and exchange of information on possible alternatives to ozone-depleting CFCs and halons. As one of the key U.S. agencies dealing with the stratospheric ozone issue, EPA will be involved in this future effort. EPA, however, has had long-standing responsibilities under section 153(b) of the Clean Air Act, as amended, to undertake research on "safe substitutes" for substances that directly or indirectly affect the stratosphere, especially the ozone in the stratosphere. In addition, EPA has statutory responsibilities under TSCA to protect the public and environment from unreasonable risks posed by chemicals used in commerce, which include CFC and halon substitutes.

Up to now, the agency's work on substitutes has mainly focused on identifying potential CFC substitutes, the time frames for their availability, and their suitability for various industrial applications. EPA has shared this information with user industries and foreign governments through meetings and reports. EPA's fiscal year 1989 Agency Operating Guidance provides for the continuation of these information-sharing efforts and also includes plans for risk assessment and risk management work on potential CFC substitutes and the evaluation of the substitutes' toxicological testing. EPA also plans to continue internal coordination on the effects of the use of CFC substitutes on EPA's air, solid waste, and water pollution programs.

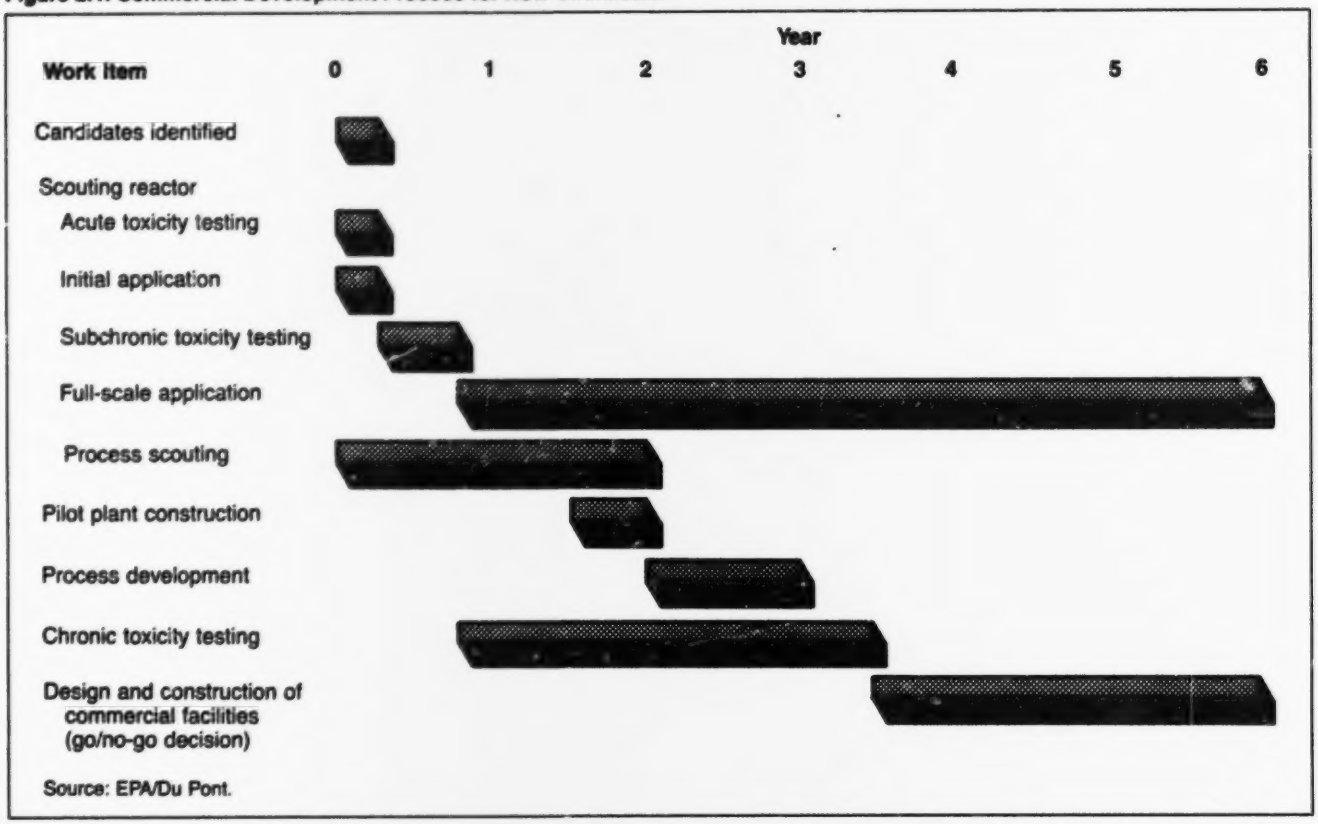
Elements of a Toxicity Evaluation

Toxicity evaluation is a key step in the development of CFC or halon substitutes, since many applications using CFCs and halons require low toxicity. As indicated in figure 2.1, which shows the steps in the commercial development of a new chemical, toxicity testing can take several years to complete.

A toxicity evaluation begins with a literature search to identify data already available on the toxicity of the chemical in question. The chemical's structure and various technical properties are ascertained, and an estimate is made of human exposure conditions. Then, three tiers of toxicological testing are performed:

- Tier one focuses on the acute effects of exposure to the chemical through inhalation, ingestion, or skin contact.
- Tier two tests for subchronic effects, providing data on genetic, systemic, carcinogenic, and developmental effects that may result from repeated exposure to the chemical.

Figure 2.1: Commercial Development Process for New Chemicals



Source: EPA/Du Pont.

- Tier three is concerned with the effects of chronic (lifetime) exposure. Carcinogenic potential is investigated, along with multigeneration reproductive toxicity. Special tests, such as cardiac sensitization, neurotoxicity, and environmental impacts, would also be done at this time.

Tier one and tier two testing is generally done early in the development process and can be completed within a year. Tier three tests take several years to complete.

After the testing is finished, the results are analyzed to determine the exposure conditions under which the chemical can be used safely. Based on these results, along with an assessment of other factors, such as production costs and potential markets, the producer makes a "go/no go" decision on whether to proceed with commercializing the chemical.

EPA's Reports on the Development of Chemical Substitutes for CFCs

Prior to the signing of the Montreal Protocol in 1987, EPA sought to identify and assess chemicals that could potentially substitute for three major ozone-depleting CFCs: CFC-11, -12, and -113. Specifically, EPA was interested in determining whether other types of CFCs, known as "non-fully halogenated CFCs" or "HCFCs," might be feasible substitutes. Unlike CFC-11, -12, and -113, these alternative fluorocarbons have lower ozone depletion potential because their chemical composition includes hydrogen, making them less stable. They tend to decompose in the lower atmosphere and consequently have much less chance of reaching and harming the stratosphere. Reports by an EPA contractor and an EPA-sponsored international committee of CFC experts indicated that some alternative fluorocarbons may prove to be successful substitutes. But they also indicated that toxicity testing on these potential substitutes was incomplete.

1987 Radian Report

EPA contracted with the Radian Corporation to provide technical information on several alternative fluorocarbons that appeared to have physical and chemical properties sought for in CFC substitutes.[1] Radian provided EPA with a draft report dated December 1986 and a final report dated September 1987.[2] The final report contains separate sections devoted to major CFC applications: automotive air-conditioning, home refrigerators, rigid and flexible foam, and solvents. It discussed the technical requirements of each application and reviewed the suitability of the selected alternative fluorocarbons to meet these requirements.

The report also looked at issues related to the commercial production of the alternatives. The report found that although alternative fluorocarbons had been synthesized in the laboratory years ago, development work on most of them had stopped because they were found to be poorer performers and more costly to produce than the CFCs currently in use. The report also included summaries of toxicological testing results for several of the potential substitutes. The data indicated that testing was incomplete, particularly for chronic effects.

[1]The chemicals reviewed were HFC-134a and HCFC-22, -123, -124, -132b, -133a, -141b, -142b, and -502. Also reviewed were CFC-114 and -115, which were eventually included among the chemicals regulated under the Montreal Protocol. As noted in the Radian report, all of these chemicals had been previously identified or studied by chemical producers and CFC users.

[2]Final Report: Technical Considerations of Applying New CFC Chemicals as Substitutes for CFC-11, 12, and 113 in Several Applications. September 1987 (DCN 87-203-068-80-10).

Preliminary Toxicity Analysis of Radian Report's Alternative Fluorocarbons

The Office of Air and Radiation (OAR),[3] which manages the stratospheric ozone protection program, requested that the Office of Toxic Substances (OTS) perform a preliminary toxicity evaluation of six alternative fluorocarbons reviewed in the Radian report.[4] OTS is responsible for reducing the risks to public health and the environment from the manufacture, distribution, and disposal of new and existing chemicals.

In March 1987, OTS provided OAR with a memorandum discussing possible health effects of the six fluorocarbons based on available information and/or an OTS structure-activity analysis. (Under the method of structure-activity analysis, a chemical's physical and chemical behavior is predicted by comparing the chemical's molecular structure with that of other chemicals for which the behavior is already known.) OTS' analysis indicated that the alternative fluorocarbons may have potential to cause adverse health effects and that additional testing was needed to determine their short-term and long-term effects on human health. For example, OTS observed that as a class, fluorocarbons are of concern for cardiotoxicity. It also noted that they are of concern for reproductive effects, citing an instance in which HCFC-133a, when tested in chronic bioassay, caused tumors and other abnormalities in the reproductive systems of male and female rats. It also noted that data showing HCFC-133a to be carcinogenic in rats suggested that three analogous HCFCs (HCFC-123, -124, and -132b) may have oncogenic (tumor-causing) concerns as well.

OTS noted that few or no acute or subchronic data were available for the six fluorocarbons reviewed. It went on to list the general types of acute, subchronic, and chronic testing that should be done to better characterize their toxicity. OTS remarked that special attention should be paid to cardiotoxicity and suggested that consideration be given to specially designed studies that would more clearly elucidate the cardiotoxic potential of the fluorocarbons.

International Committee Report on CFC Chemical Substitutes

EPA pursued the issue of chemical substitutes by convening, in February and April 1987, an international committee of experts on CFC chemistry, toxicology, production, and marketing. The experts were drawn from both industry and academia. As with the Radian report, the committee's objectives were to identify the most promising substitutes for CFC-11,

[3]Toward the end of our audit, this office was reorganized under a new name, the Office of Atmospheric and Indoor Air Programs.

[4]The fluorocarbons reviewed were HFC-134a and HCFC-123, -124, -132b, -133a, and -141b.

-12, and -113. The committee was also asked to determine the factors that influence the commercialization of such substitutes and make recommendations to expedite their development. In its April 1988 final report, the committee provided EPA with formal findings and recommendations as well as individual opinions.[5]

The committee concluded that the leading candidates for substitutes among the alternative fluorocarbons were HCFC-123 (to replace CFC-11) and HFC-134a (to replace CFC-12), mainly because acute toxicity testing (tier one) for both chemicals had been completed, as had subchronic tests (tier two) for HCFC-123. Also, some development work had been done on the chemicals' larger-scale synthesis. The committee nevertheless was concerned about the possibility that promising alternative fluorocarbons might have to be withdrawn from consideration if the toxicological tests remaining to be done indicated adverse health effects. The committee identified a number of fluorine compounds that might be suitable backup chemicals to the most promising alternative fluorines. The committee cautioned, however, that "there was almost no toxicological data or technical performance data on many known fluorocarbon materials that would appear to have the physical properties necessary for use as substitutes."

Project on Chemical Substitutes

The international committee recommended that research be done on likely alternative chemical compounds from nontraditional areas of chlorofluorocarbon and fluorocarbon chemistry. Accordingly, EPA and the Electric Power Research Institute are co-funding a research project involving the synthesis of novel fluorinated compounds and the determination of their relevant chemical, physical, and thermodynamic properties. The aim of this project is not to perform detailed development testing, but to explore in a preliminary way possible "back-up" CFC alternatives for private industry to pursue as individual companies deem appropriate. During the summer of 1988, following a request for proposals, EPA awarded research grants to the University of Tennessee and Clemson University. According to the EPA project officer, the entire research effort is expected to last 3 years. He said that EPA and the Electric Power Research Institute are each contributing $106,000 for the first year of research and will make funding decisions for the second and third years as the work progresses, though he expects subsequent grant amounts to be close to the first-year level.

[5]Findings of the Chlorofluorocarbon Chemical Substitutes International Committee. April 1988 (EPA-600/9-88-009).

Chemical Producers' Testing of Alternative Fluorocarbons

Although chemical substitutes for halons have not been identified, chemical producers are making important progress in developing chemical substitutes for CFCs. The producers agree on the need to test these potential CFC chemical substitutes for safety, and such testing is currently underway at individual companies. In addition, several domestic and foreign companies are jointly funding two testing programs on selected substitutes in order to expedite the testing process. Some results of testing done by individual companies have been made available, but in general most of the tests are not expected to be completed for several years.

Testing Being Done by Individual Companies

In December 1987, EPA requested that domestic producers of CFCs and halons voluntarily provide a listing of the substitutes that they are working on, their toxicological testing plans, and the results obtained so far. Of the seven domestic producers involved, five responded to this request, while two did not. Because the responses are classified as confidential business information, we cannot release their specifics. Taken as a whole, however, the data indicates that several of the producers are actively testing a number of alternative fluorocarbons.

Chemical producers have made public some of their toxicity testing results. In January 1987, Du Pont reported to the Chairman of the House Subcommittee on Health and the Environment, Committee on Energy and Commerce, that three alternative fluorocarbons—HCFC-21, -31, and -133a—had been disqualified from further consideration because preliminary testing indicated unacceptable toxicity. HCFC-133a was one of the chemical substitutes of concern in OTS' preliminary toxicity evaluation, discussed earlier. In May 1987, during hearings before the Senate Subcommittees on Environmental Protection and Hazardous Wastes and Toxic Substances, Committee on Environment and Public Works, Du Pont reported that some preliminary adverse indications had been obtained during the testing of HCFC-132b, another of the chemicals of concern in OTS' preliminary toxicity evaluation. Another chemical producer, ICI, announced that it will not sell HCFC-22 for aerosol use in personal care products because of some adverse toxicological testing results.

Producers' International Testing Program

In January 1988, more than a dozen U.S., European, and Japanese chemical companies announced a program to jointly fund toxicity tests on selected fluorocarbons that appeared to have chemical and physical properties suitable for use as CFC substitutes. The declared purpose of

this Program for Alternative Fluorocarbon Toxicity Testing (PAFT) is to assure the safety of the most promising substitutes in order to hasten their commercial development. PAFT members chose two fluorocarbons for joint review: HCFC-123 and HFC-134a. (These are the same chemicals identified by EPA's international committee of CFC experts as being strong candidates to replace ozone-depleting CFCs in some applications.)

The chairman of PAFT told us that PAFT members meet quarterly to plan their activities. Last May they agreed on contracts with major testing laboratories to carry out a toxicity testing program developed by PAFT. A list of the tests to be performed has not been made public, but the chairman told us that the tests are all "standard." The initial tests are for acute toxicity, eye and skin irritation, mutagenicity, and the establishment of dose levels for chronic, 2-year inhalation studies. In a letter to EPA, the chairman stated that testing would begin in 1988 and should be completed within 5 to 7 years.

In addition to this testing effort, a second cooperative program to develop toxicity profiles on another fluorocarbon, HCFC-141b, is being jointly funded by a smaller international group of producers, some of whom are members of the first testing program. Testing on HCFC-141b is scheduled to begin in 1988, with completion in about 5 years.

Chemical Substitutes Other Than Alternative Fluorocarbons

As part of the Regulatory Impact Analysis developed for EPA's rulemaking on CFCs and halons, OAR identified more than two dozen industrial chemicals, other than alternate fluorocarbons, that are currently in use and, according to OAR, technically capable of substituting for CFCs in some applications. These chemicals, along with their possible applications, are listed in table 2.1. OAR factored the availability of these other chemicals into its cost estimates for restricting CFC and halon production.

Table 2.1: Other Chemicals Identified by EPA as Technically Feasible CFC Substitutes in Certain Applications

Solvents	**Sterilization**
Napthas	Carbon dioxide
Methyl chloroform	Ethylene oxide
Methylene chloride	
Perchloroethylene	**Flexible foam**
Trichloroethylene	Methylene chloride
Ethanol	Formic acid
Isopropanol	
Methanol	**Rigid foam**
Acetone	Azodicarbonamide
Benzol (benzene)	n-Pentane
2-ethoxyethanol (Cellosolve)	n-Butane
Chloroform	Isopentane
Carbon tetrachloride	Hexane
Mineral spirits	
Stoddard solvent	
Toluene	
1,1,2 trichloroethane	
Refrigeration	
Dimethyl ether	
Ammonia	
Helium (leak testing)	

Although these other chemicals are currently available and in use, they are not without safety concerns. Because of these safety concerns, they may not be desirable alternatives, regardless of their technical feasibility as substitutes. OTS officials told us that several of the chemicals are involved in regulatory actions. Hexane, methyl chloroform, and isopropanol are involved in testing actions under section 4 of TSCA. Methylene chloride, perchloroethylene, and trichloroethylene are chlorinated solvents that are being reviewed for possible regulation due to adverse health effects. Ethylene oxide, used in sterilization, is a carcinogen and will be regulated by EPA. The chemical 2-ethoxyethanol has reproductive toxicity problems and has been referred to the Occupational Safety and Health Administration (OSHA) for regulation in the workplace. Carbon tetrachloride, in addition to being a potent liver and kidney toxin, has been cited as being a depleter of stratospheric ozone.

OAR staff told us that they recognize that some of the chemical substitutes listed in the Regulatory Impact Analysis have safety concerns. The staff stressed to us that these chemicals were identified not to provide industry with a list of recommended options, but to develop regulatory cost/benefit calculations based on possible options that industry could take from a technical standpoint. In calculating the costs, the staff maintain that they took into account the cost of additional safety measures that might be needed when using some of these substitutes.

This approach has resulted in criticism from industry over just what EPA's message was regarding the current availability of substitutes. Industry officials told us that EPA was acting inconsistently by mentioning, as possible substitutes, chemicals that the agency may subsequently regulate because of safety or pollution concerns. OAR was more circumspect in its May 1988 report, How Industry Is Reducing Dependence on Ozone-Depleting Chemicals. This report mentions only a few of the industrial chemicals from table 2.1, and the safety issues associated with them are explicitly recognized. For example, the report notes that methylene chloride, currently used as an auxiliary blowing agent with CFC-11 for manufacturing flexible foam slabstock, is suspected of being a carcinogen and therefore is not expected to be a significant substitute for CFC-11. EPA also stated in August 1988 that it does not consider the increased use of chlorinated solvents currently under regulatory scrutiny to be an acceptable alternative to CFCs.[6]

Nevertheless, the safety issue remains a key one for these chemicals, as well as for the alternative fluorocarbons. EPA recognizes this and believes that it must play an active role in assessing the safety of chemical substitutes for CFCs and halons.

EPA's Approach to Assessing CFC and Halon Substitute Safety

In late 1987, shortly after the Montreal Protocol was signed and prior to its ratification internationally in late 1988, OAR and OTS began to develop a coordinated assessment approach aimed at ensuring that CFC and halon substitutes do not create new health and environmental problems. Although TSCA provides EPA with regulatory authority concerning the safety of chemicals used in commerce, few alternative fluorocarbons identified so far as likely potential substitutes fall under the TSCA provisions requiring a premanufacture safety review by EPA. To address this situation, OAR and OTS staff during 1988 worked on developing a special approach for reviewing the safety of likely substitutes.

After considering various options, the two offices reached agreement in November 1988 on steps "to ensure the introduction of safe substitutes." These steps include some use of EPA's TSCA review authority, an internal EPA assessment of available health and safety data on likely potential substitutes, and the identification by EPA of testing needs for these substitutes. In addition, EPA plans to seek industry's voluntary

[6]This statement appears in Protection of Stratospheric Ozone: Advance Notice of Proposed Rulemaking (53 Fed. Reg. 30617).

cooperation in providing data needed for EPA's assessment, along with its own views on assessment issues and needs.

Few Potential CFC Substitutes Are Subject to TSCA New Chemical Review

TSCA gives EPA comprehensive regulatory authority over chemicals used in commerce, including CFC substitutes.[7] It authorizes EPA to take steps to identify potentially harmful chemicals, gather information on their use and safety, and take appropriate control actions for those chemicals found to present an unreasonable risk to human health and the environment. However, the authorities provided under TSCA for regulating existing chemicals and new chemicals differ. "Existing" chemicals are defined under the provisions of TSCA as those that are listed in the TSCA Chemical Substance Inventory, which includes over 62,000 chemicals. "New" chemicals are defined as those not listed in the inventory.

While some CFC substitutes are new chemicals, most of them are existing chemicals because they are listed in the inventory (even though some have never been commercially produced). This fact has important ramifications for EPA's effort to review the safety of substitutes for ozone-depleting chemicals since, for the most part, only new chemicals are routinely subject to an EPA safety review before they are commercialized.

Review Authority for New Chemicals

Under section 5 of TSCA, any person who intends to manufacture or import a new chemical for commercial purposes in the United States must submit a notice called a "premanufacture notification" (PMN) to EPA at least 90 days before beginning manufacture. TSCA specifies that the notification include information available to the producer on the chemical's identity, intended uses, and health and environmental effects. EPA has 90 days (extendable to another 90 days) to review the notification and assess whether or not the new chemical presents or may present an unreasonable risk to human health or the environment. If EPA decides that additional data are needed to make this assessment, it can control the use of the chemical until the data are provided. If EPA determines that the chemical does in fact present an unreasonable risk, it is required to take control actions ranging from requiring labeling to banning the chemical. Once the chemical successfully goes through the premanufacture notification review process, it is considered an existing

[7]TSCA applies to all chemical substances except pesticides, tobacco, nuclear material, firearms and ammunition, food, food additives, drugs, and cosmetics, which are covered by other laws administered by EPA and other federal agencies.

chemical and is put in the TSCA inventory of existing chemicals. Unless EPA has stipulated control measures as a result of its premanufacture notification review, the chemical can be produced by anyone, for any purpose, in any amount without submission of further notifications or additional EPA safety review.

While the premanufacture notification review provides EPA with an initial opportunity to screen a new chemical for safety, only a few potential CFC substitutes are "new chemicals" subject to this review process. Most of the potential CFC substitutes identified by EPA—both the alternative fluorocarbons and other industrial chemicals—are in the TSCA inventory of existing chemicals.[8]

Review Authority for Existing Chemicals

TSCA provides EPA with several authorities to obtain data for assessing risks that may be posed by chemicals in the TSCA inventory of existing chemicals. Producers must report to EPA any information on adverse health effects of their chemicals. Also, section 8(d) of TSCA authorizes EPA to require producers to provide EPA with their unpublished health and safety studies.[9] If EPA finds that a chemical could present an unreasonable health or environmental risk (or if there may be substantial human or environmental exposure to the chemical) and if testing is needed to develop sufficient data to determine the risks, EPA can use section 4 of TSCA to require chemical producers to perform such tests. Section 6 of TSCA authorizes EPA to take actions—ranging from labeling to a complete ban—to control the use of chemicals that it determines present an unreasonable risk to human health or the environment. However, until an existing chemical is shown to pose such a risk and appropriate control actions are implemented by EPA, the chemical can be produced by anyone, in any amount, and for any use without notification to EPA.

There is an important TSCA provision, however, which gives EPA the opportunity to review the safety of chemicals in the TSCA inventory

[8]Among the alternative fluorocarbons, for example, HCFC-141b is considered a new chemical, while HFC-134a and HCFC-22, -123, and -142b are listed as existing chemicals. The chemicals listed in table 2.1 are also existing chemicals.

[9]EPA defines "health and safety study" to mean "any study of any effect of a chemical substance or mixture on health or the environment or on both, including underlying data and epidemiological studies, studies of occupational exposure to a chemical substance or mixture, toxicological, clinical, and ecological or other studies of a chemical substance or mixture, and any test performed under TSCA. . . . Any data that bear on the effects of a chemical substance on health or the environment would be included." (40 C.F.R. 716.3).

prior to their being put to new uses. By imposing a "significant new use rule" (SNUR) under section 5(a)(2) of TSCA on a specified existing chemical, EPA can require producers to notify the agency in advance of a significant new use of that chemical. The producer must provide information on the chemical, including its composition, projected volumes and worker exposure, and any available test data. If EPA decides that the information submitted is inadequate to assess whether the significant new use is safe, EPA can require that testing be done to collect additional data. The SNUR also gives EPA authority to put a hold on the chemical's new use while the data are being gathered and evaluated.

At present, none of the alternative fluorocarbons in the TSCA inventory of existing chemicals have SNURs attached to them. Consequently, they can be produced by anyone, in any volume, and for any use without an EPA safety review.

Development of the November 1988 Assessment Memorandum

Recognizing that special actions would have to be taken to assess potential substitutes classified as existing chemicals, staff from OAR and OTS considered various approaches to assessing the safety of existing chemical substitutes, as well as new chemical substitutes. As indicated in the internal memorandums from December 1987 to September 1988, summarized in appendix II, the staff discussed the scope that their effort should take, the organizational forum that should deal with the assessment issue, and options for gathering data needed to assess the chemicals—including voluntary data-sharing agreements with chemical producers, formal TSCA data-collection rulemakings, or a combination of both. Several months passed before OAR and OTS staff got deeply into the assessment issue, but by July 1988 the pace of OAR's and OTS' efforts quickened and a concerted effort was made to reach closure on the assessment approach to be used. By September 1988, OAR and OTS staff had developed an approach which, with some modification, was adopted in a November 2, 1988, coordination memorandum from the Acting Assistant Administrator for Air and Radiation to the Acting Assistant Administrator for Pesticides and Toxic Substances.

Assessment Goals

The November 1988 memorandum set several broad assessment goals. The overall goal of OAR's and OTS' coordinated efforts is "to ensure the introduction of safe substitutes"—that is, substitutes that present no "unreasonable risks." The memorandum stressed that "[a]ny long-term solution must not create new health or environmental problems." The

memorandum also noted the importance of early EPA involvement in testing decisions for the substitutes "to ensure that testing needs for both new and existing substitutes are identified using consistent approaches, that needed testing is properly performed, and that evaluations of test data on the substitutes are performed in a consistent manner." Early review is important to ensure that any disagreements between EPA and chemical producers over testing are raised and resolved quickly in order to avoid unnecessarily delaying the introduction of safe substitutes.

EPA's Review of New Chemical Substitutes

New chemical substitutes are to be identified and assessed through the normal premanufacture notification review required under section 5 of TSCA, described earlier. According to the November 1988 memorandum, when a premanufacture notification is received by OTS, OTS staff will analyze the chemical from technical and economic standpoints to determine whether the chemical is intended to, or could potentially, replace CFCs for specific uses. If so, OTS will invite OAR representatives to participate in "the standard OTS new chemical review process."

EPA's Review of Existing Chemical Substitutes

Existing chemical substitutes are to be dealt with through special assessment activities, which are the principal concern of the November 1988 memorandum. According to the memorandum, likely existing chemical substitutes for CFCs and halons will be identified by OAR or through industry sources and will undergo the following assessment process. OTS will review the existing chemical literature and toxicity data and prepare a report summarizing the available data, relative toxicity, and important unresolved toxicity concerns presented by each of the identified substitutes. OTS will then identify a proposed set of tests, along with appropriate testing protocols, that should be performed to provide sufficient data to assess the health and environmental risks of the substitutes. These testing needs and protocols will be reviewed internally by EPA's Testing Priority Committee.[10] OTS, in consultation with OAR, will resolve any additional testing needs or technical issues identified by the Testing Priority Committee.

OTS and OAR will provide the results of their work to industry, as well as to the two international joint testing groups, and advise them of EPA's

[10]This standing committee, made up of representatives of major EPA offices, meets every 2 to 3 months to discuss safety and testing issues concerning existing chemicals. According to the November 1988 memorandum, meetings of the Testing Priority Committee dealing with CFC substitutes will be co-chaired by OAR and OTS.

information needs. As characterized in the memorandum, EPA will "strongly urge" industry to provide its own views on risk assessment issues and data needs, summarize their ongoing testing, and describe their test rationale.

Time Frames Not Specified, but Some Work Has Begun

The November 1988 memorandum does not include time frames for the assessment activities mentioned, such as the development of OTS' planned toxicity report on existing chemical substitutes. OAR and OTS staff noted, however, that some work on reviewing both new and existing chemicals has started.

Regarding the review of new chemicals, OTS staff told us that their office received several premanufacture notifications during 1988 for new alternative fluorocarbons. (The identity of these chemicals is confidential business information.) The staff said that they have already put one of these chemicals through its standard "new chemical" technical review, which considers the available data on toxicity, structural analogues, potential exposures, and risks. Following an evaluation of structural analogues, potential exposures, and test data submitted by the producer, OTS reached a preliminary decision to prohibit the commercialization of the chemical until much more toxicological data could be provided. At the producer's request, EPA suspended its review process to give the producer time to submit additional toxicological data. Consequently, as of early December 1988, no final decision had been made on this chemical by OTS.

The OTS staff said that the other alternative fluorocarbon premanufacture notifications will undergo a similar new chemical review process.

The review of existing chemical substitutes has gone slower. During the summer of 1988, while still working out their overall approach to the safety assessment issue, OAR and OTS agreed to conduct a preliminary assessment of two existing alternative fluorocarbons currently in commercial use (HCFC-22 and -142b). According to the staff, OAR is to gather available toxicological data summaries from producers on these chemicals. OTS will then run the data through its toxicological scoring system to gauge the magnitude of hazard associated with these chemicals. This scoring system is not meant to be a mechanism for making ultimate risk decisions, but is a tool for identifying chemicals needing additional scientific evaluation. OAR hoped to have data from the domestic producers of these two chemicals by August 1988. Although some data was

received, OAR was still waiting for additional producer data during November 1988.

Integration of Toxicity and Ozone Depletion Concerns to Be Addressed Case by Case

The issue of how to integrate ozone-depletion concerns and traditional toxicity concerns in the substitute safety assessment process is a key one because EPA is both discouraging the use of ozone-depleting chemicals and making safety assessment decisions that affect what substitutes are available and when. As the office responsible for making these assessments, OTS is particularly concerned about the tension caused by the desirability of moving away from CFCs quickly and the need to satisfy traditional toxicological concerns for the safety of the chemicals intended to replace them.

The November 1988 memorandum does not address the issue of how to integrate toxicity and ozone depletion risk assessments. This issue was discussed, however, in an internal memorandum to the EPA Administrator from the Acting Assistant Administrator for Pesticides and Toxic Substances and the Acting Assistant Administrator for Air and Radiation. The purpose of this memorandum, dated November 29, 1988, was to inform the Administrator about emerging CFC issues, particularly in regard to the review of premanufacture notifications for new chemical substitutes currently underway in OTS. The memorandum stressed that OTS "intends to balance concerns for ozone depletion against significant 'traditional toxicity' concerns such as worker and consumer exposure to potential carcinogens or developmental toxicants," adding that "OTS is working closely with OAR to assure that the two programs develop an integrated approach to the issues."

OTS and OAR staff told us that the integration of toxicity and ozone-depletion concerns will be addressed on a case-by-case basis as they review individual chemical substitutes. OTS staff emphasized that particular factors need to be considered in assessing each substitute, such as the quality of the traditional toxicity testing done on the chemical in question, data on analogous chemicals, types of potential exposures, exposure controls available, the need for the substitute, and the regulatory controls available to allow the safe exploration of the markets for the substitute.

The memorandum cautions the Administrator that "OTS decisions on both the new and existing chemical aspects of regulation of CFC-substitutes have the potential to affect the goals and policies of the Agency program on ozone depletion, as expressed in the Montreal Protocol and

your recent press statement, possibly altering the rate of substitution and the identity of the substitutes."[11] At present, this remains only a potential policy problem. As noted earlier, the review of substitute safety was still in early stages at the time our audit work concluded in late 1988, with no final assessment decisions having been made for any of the alternative fluorines.

EPA Should Rely More on TSCA Authorities in Assessing Substitute Safety

EPA's November 1988 memorandum does not call for the use of TSCA authorities to require producers to provide EPA with their unpublished health and safety studies on CFC and halon substitutes, or to report significant new uses of existing chemicals as substitutes. Instead, it states that OTS, in consultation with OAR, "will evaluate the role of regulatory approaches available under TSCA to ensure that appropriate data on existing CFC/halon substitutes are developed in a timely manner, and that any potential unreasonable risks to health and the environment are addressed."

Given the importance of the safety issue, we believe that EPA's approach to assessing the safety of CFC and halon chemical substitutes should include the use of two TSCA authorities mentioned earlier: section 8(d), which authorizes EPA to require producers to submit unpublished health and safety studies to EPA, and section 5(a)(2), which gives EPA review and control authority over significant new uses of specified existing chemicals. Use of these two TSCA authorities would help EPA meet its assessment goal of ensuring that the producers' testing is done correctly and consistently for both new and existing chemical substitutes. EPA would also be able to quickly control significant new uses of existing chemical substitutes that pose an unreasonable risk to human health and the environment.

Use of TSCA Authority for Obtaining Health and Safety Studies

The November 1988 memorandum does not mention promulgating a TSCA section 8(d) rulemaking to require producers to provide EPA with their unpublished health and safety studies for CFC and halon substitutes. Instead, as noted earlier, EPA plans to advise industry of EPA's information needs. OAR and OTS officials maintain that EPA can obtain

[11] In a September 26, 1988, press release marking the issuance of EPA's report, Future Concentrations of Stratospheric Chlorine and Bromine, the EPA Administrator stated: "The depletion that has already occurred calls into question our earlier projections of future damage. We must go further than a 50-percent reduction in these chemicals in order to stabilize ozone levels." He recommended a global response through the provisions of the Montreal Protocol to further reduce the use of ozone-depleting CFCs and halons.

testing information faster through an informal, voluntary arrangement with industry, than through a formal section 8(d) rulemaking. They believe that the producers will cooperate with this voluntary approach, given the glare of publicity on the stratospheric ozone issue.

However, EPA has yet to demonstrate that it can obtain complete testing information on CFC and halon substitutes through voluntary reporting. As discussed earlier, EPA's previous attempt in December 1987 to obtain testing information voluntarily from the seven domestic CFC and halon producers was not completely successful, since two producers would not respond with the requested data. EPA made followup requests to both producers. One producer did not respond, even after a second followup request. The other producer replied in February 1988 that it would supply the requested testing information by March. However, this information was not supplied. In June 1988, after followup by EPA, the producer replied that it was a member of PAFT, the international testing group discussed earlier. The producer referred EPA to the chairman of PAFT for information regarding its testing. Other producers who had responded to EPA's original request also mentioned their involvement in PAFT, but provided no details on the testing plans that were being developed by PAFT.

The chairman of PAFT told us that the PAFT protocol prohibits any one member company from disclosing testing information. He added, though, that the protocol recognizes that this restriction can be superceded by any regulations in a particular country that require a company to report toxicity information. In a January 1988 letter to the EPA Administrator, the PAFT chairman stated that "[i]t is intended that the results from the test programs will be published in the open literature. In addition, any significant interim results will be promptly communicated to regulatory authorities as required by law" [emphasis added].

EPA did not contact PAFT about its testing program until after the November 1988 assessment memorandum was signed. In a December 5, 1988, letter to the PAFT chairman, EPA invited PAFT representatives to meet with EPA staff "to present your on-going activities and future plans for toxicity testing of the chemicals covered by your organizations." This meeting was in the process of being scheduled when we concluded our audit work.

We recognize that it is important that EPA review the producers' testing plans as quickly as possible, especially given the fact that the producers' testing is well underway and EPA was slow in coming to closure on how

to approach the safety issue. However, we believe that the reporting of health and safety studies should be put on a formal basis. We believe that TSCA section 8(d) authority is an appropriate vehicle for obtaining health and safety information from PAFT members doing business in the United States and subject to TSCA, as well as from domestic chemical producers and importers who are not members of PAFT. Use of section 8(d) would establish an ongoing regulatory mechanism to provide EPA with health and safety studies on substitutes on a timely basis over the coming years. This is a particularly important point since the substitute safety issue will take years to resolve due to the long-term nature of the testing and the likelihood that a series of substitutes will be developed over several years to replace the regulated CFCs and halons.

In recent testimony before the House Subcommittee on Environment, Energy, and Natural Resources, Committee on Government Operations, the Director of OTS noted that EPA implements its section 8(d) authority by means of a "model" rule to which chemicals can be added, thereby allowing EPA to gather health and safety data "in a relatively easy fashion."

Use of TSCA Authority to Review and Control New Uses of Existing Chemical Substitutes

EPA's November 1988 assessment approach also does not call for the use of TSCA section 5(a)(2) to promulgate SNURs on any of the chemical substitutes. We believe that SNURs are warranted in the case of alternative fluorocarbons that are currently in the TSCA inventory of existing chemicals, as well as fluorocarbons that may later be added to the inventory following a premanufacture notification review. We also believe that chemical substitutes other than alternative fluorocarbons, such as those in table 2.1, should be considered for SNURs, depending on their known toxicity, exposure levels, and exposure situations as substitutes in CFC applications.

SNURs, in essence, provide EPA with review and control authorities over specified existing chemicals similar to the premanufacture review for new chemicals required under TSCA. SNURs would ensure that EPA is notified before existing alternative fluorocarbons and other existing chemicals are put to new significant uses as CFC and halon substitutes, and they would give EPA the opportunity to review the producers' health and safety data to determine whether the chemicals could be used safely in the particular exposure situations that the new uses involve. This authority is also useful in the case of new fluorocarbons that undergo premanufacture notification review and are subsequently added to the

inventory. A SNUR would enable EPA to monitor changes in the manufacture and use, and thus exposure, of these newer chemicals.[12] Also, unlike section 8(d) authority, which is limited to data-gathering, SNURs enable EPA to quickly control significant new uses of the substitutes, if deemed necessary to protect human health and the environment.

During the summer of 1988, OTS considered the pros and cons of putting SNURs on CFC substitutes. OTS noted that SNURs would ensure "discovery" of the use of substitute chemicals and provide for their easy and immediate control, as necessary. OTS also considered the issue of whether there can be a "level playing field," in terms of requiring testing or imposing restrictions, unless SNURs are put on existing CFC substitutes. This concern is reflected in the November 29, 1988, EPA internal memorandum summarizing emerging CFC issues, mentioned earlier. In that memorandum, the EPA Administrator was told that an "issue of concern is the equivalent treatment under TSCA of producers of new CFC[s] (and CFC substitutes) and producers of Inventory chemicals [i.e., existing chemicals] for which usage volume may increase or for which new uses may be planned." The memorandum noted that the resolution of this issue may be "particularly sensitive."

Without SNURs, only new chemical substitutes would be routinely subject to review before commercialization. An existing substitute that had never been commercialized would face no such review unless a SNUR is imposed on it. Promulgating SNURs on alternative fluorocarbons and other chemical substitutes listed in the TSCA inventory of existing chemicals would essentially bring them into a similar review process as the "new" fluorocarbons and would, therefore, help EPA meet its declared assessment goal of having both new and existing chemical substitutes undergo consistent testing and review before being used commercially.

Whether EPA will eventually use SNURs for CFC and halon substitutes remains an open issue. OTS told us that SNURs are cumbersome rules to develop, promulgate, and implement. Part of the difficulty in developing a SNUR involves the need to fine-tune the SNUR to capture adequately the specific chemicals and uses of concern. According to OTS staff, a SNUR rulemaking can take 6 to 8 months if there are no problems, but a year is more common. However, OTS is currently promulgating an expedited procedure for SNURs that will abbreviate the SNUR review and development

[12]In an earlier report, Assessment of New Chemical Regulation Under the Toxic Substances Control Act (GAO/RCED-84-84, June 15, 1984), we discussed the advantages of using SNURs to monitor changes in the manufacture and use of new chemicals that have undergone EPA's premanufacture notification review and have been added to the TSCA inventory of existing chemicals.

process. OTS expects to publish this new procedure as a final rule by the end of 1988.

EPA's Work on Environmental Effects of Substitutes Is Focused on Regulatory Issues

EPA has done limited assessment work on the potential effects of substitutes on the atmosphere and environment. OAR officials maintain that the substitutes should not present atmospheric problems because of their small volumes and long lifetimes in the lower atmosphere. Consequently, OAR has not initiated work on the atmospheric chemistry of substitute chemicals. It has, however, had EPA scientists review certain CFC substitutes to determine whether they need to be regulated as ground-level air pollutants. OAR will also continue to examine regulatory issues associated with the possible recycling of CFC refrigerants and will work with other EPA offices to evaluate the possible water pollution effects of aqueous cleaning of electronics or use of alternative solvents.

Potential Atmospheric and Environmental Effects

Program officials in OAR believe that CFC substitutes should not have significant environmental effects, such as contributing to acid rain, because their presence in the atmosphere would be minuscule and the emissions dispersed globally due to the relatively long lives of the chemicals. They stated that they do not see a plausible place for EPA to spend research money on this issue.

Some information has been developed on the contribution that alternatives may make to global warming (the "greenhouse effect"). Du Pont has reported measurements of the relative greenhouse potential of the regulated CFCs and halons, and about a dozen HCFCs, some of which are promising substitutes. Du Pont's data indicate that the potential for these chemicals to contribute to the greenhouse effect is smaller than for the CFCs they may replace. For example, whereas CFC-11 is assigned a greenhouse potential value of 0.4 and CFC-12 a value of 1.0, HCFC-123, -141b, and HFC-134a are assigned values of < 0.1.

Some concerns about the atmospheric chemistry and environmental fate of CFC substitutes were raised in the report of EPA's international committee of CFC experts, discussed earlier. The committee found that "there is very little knowledge of the atmospheric chemistry of new alternative compounds other than generalizations which apply to groups. . . . [and] even less knowledge concerning the ultimate fate in the environment of such species as [H]FC-134a." Accordingly, the report recommended that research be done on the tropospheric (lower atmosphere) chemistry of the primary substitutes, HCFC-123 and HFC-134a, as

well as other promising chemicals to determine, among other things, their acid toxicity and breakdown products. The report also noted a great need to fund research to determine the ultimate environmental fate of alternative fluorocarbon materials such as HFC-134a and HCFC-123.

According to OAR officials, these views primarily reflected the concerns of one of the committee members and not the whole committee. Currently, there are no EPA plans to test the atmospheric chemistry and environmental fate of the alternative fluorocarbons. OAR believes that the producers should be the ones to work on this.

Several producers, in fact, intend to address this issue. On December 9, 1988, an international group of 14 producers announced the formation of the Alternative Fluorocarbon Environmental Acceptability Study (AFEAS). The group plans to conduct an in-depth review of current scientific knowledge regarding the environmental acceptability of eight alternative fluorocarbons. The review will focus on the potential impact of the alternatives and their degradation products on stratospheric ozone, global warming, and acid deposition (acid rain). AFEAS stated that it plans to report its findings in mid-1989 and publish a final report in early 1990. It added that interim reports will be issued at appropriate stages of the study.[13]

Ground-Level Air Pollution

During May 1988, OAR asked EPA's Atmospheric Sciences Research Laboratory to determine the extent to which several alternative fluorocarbons were volatile organic compounds (VOCs). VOCs contribute to ground-level air pollution and are subject to inventorying and control requirements under the Clean Air Act.[14]

The results indicated that the alternative fluorocarbons reviewed are negligible VOCs. OAR told us that a draft notice is under review for issuance in the Federal Register that would add these alternative fluorocarbons to a list of chemicals exempted from inclusion in state

[13]The alternative fluorocarbons to be evaluated are HFC-125, -134a, and -152a; and HCFC-22, -123, -124, -141b, and -142b. Most of the members of AFEAS are also members of one or both of the international joint toxicity testing programs, discussed earlier.

[14]The alternative fluorocarbons reviewed were HFC-134a and HCFC-123, -141b, and -142b. In addition, two alternative solvents were reviewed: water soluble terpene and a CFC-113/methanol blend. These latter two are not included for exemption in the draft notice. [On January 18, 1989, as our report went to press, EPA's exemption notice for these four chemicals was issued (54 *Fed. Reg.* 1997).]

implementation plans for attaining and maintaining national ambient air quality standards. EPA hopes to issue this exemption notice by the end of 1988. A similar exemption was granted several years ago to the ozone-depleting chemicals CFC-11, -12, -113, -114, and -115, which were also determined to be negligible VOCs.

Recycling and Water Quality Issues

OAR staff have met with staff from other EPA offices to discuss ways in which CFC regulation might affect other regulatory efforts. OAR is seeking clarification on whether CFCs recovered from refrigeration equipment for the purposes of recycling would be considered a hazardous chemical substance under provisions of the Resource Conservation and Recovery Act (RCRA) and thus subject to RCRA regulations. Although this issue is still under review, OAR staff told us that so far it appears that recovered refrigerants would not be considered a hazardous substance.

Another issue involves the use of alternative solvents and water to clean electronics in place of CFC-113. OAR is working with EPA staff responsible for water quality issues on the need to investigate the impact of alternative solvents and aqueous cleaning processes on wastewater treatment facilities.

Chapter 3 of this report goes into more detail on OAR's projects involving the conservation and recycling of CFCs and halons, and technological alternatives to their use.

Conclusions

Impending international regulation of CFCs and halons caused chemical producers to accelerate their work on developing substitutes for ozone-depleting chemicals. Part of the development process involves testing potential substitutes to determine whether they could have adverse effects on human health. Two EPA-sponsored reports and EPA's own preliminary toxicological evaluation noted the incompleteness of the existing toxicological data on alternative fluorocarbons. The toxicological evaluation also noted concerns about potential adverse health effects suggested by both the available tests and structure-activity analyses of the chemicals.

Although the chemical producers are testing CFC alternatives both individually and as part of two international joint testing programs, EPA still has statutory responsibilities under TSCA to see that CFC and halon substitutes do not present unreasonable risks to human health and the environment. By November 1988, EPA had developed an approach for

assessing the safety of chemical substitutes for CFCs and halons. This approach calls for the agency to examine existing literature and toxicity data on potential substitutes, identify tests that should be performed to assess the health and environmental risks of such substitutes, and advise the producers of EPA's information needs. EPA will strongly urge the chemical producers to provide their views on assessment issues, summarize ongoing testing and test plans, and describe their rationale. EPA recognizes that concern over the ozone-depletion problem is causing tension between the need to stop further ozone depletion quickly and the need to satisfy traditional toxicological concerns over the safety of chemicals used as CFC and halon substitutes. EPA intends to deal with the integration of ozone-depletion concerns and substitute toxicity concerns on a case-by-case basis as it assesses individual CFC and halon substitutes. No time frames were specified for the assessment activities, but some review work is currently underway.

EPA's assessment approach does not include the use of TSCA authority to require producers to provide EPA with their unpublished health and safety studies on potential CFC and halon substitutes. EPA staff maintain that they can obtain the information needed for their assessment more quickly through voluntary cooperation with the producers than through the formal TSCA rulemaking process. However, EPA's previous attempt to gather testing information on CFC and halon substitutes resulted in incomplete data. EPA's approach also does not include the use of TSCA authority to provide EPA with an opportunity to review the safety of existing chemicals intended for significant new uses as CFC substitutes and to enable the agency to quickly control intended new uses that pose a risk to human health and the environment. Instead, EPA intends to evaluate the role of regulatory approaches available under TSCA to ensure that appropriate data on the safety testing of substitutes is developed in a timely manner and that any potential unreasonable risks to human health and the environment are addressed. In the meantime, though, most of the potential CFC substitutes identified so far can be produced by anyone, in any amount, and for any use, without prior notification to EPA or an EPA safety review.

Adequate information-gathering on the producers' health and safety studies is an essential first step in EPA's assessment of CFC and halon substitute safety. Use of TSCA section 8(d) authority would require producers to provide EPA with their unpublished health and safety studies on substitutes in a timely, ongoing manner. Such data would help EPA decide whether further testing is needed to determine the safety of chemical substitutes (particularly alternative fluorocarbons currently

being tested by producers) and whether control measures on their use are needed to protect human health and the environment. In addition, use of TSCA section 5(a)(2) authority would require producers to provide EPA with advance notification of intended significant new uses of existing chemicals as substitutes for CFCs and halons. EPA could then review the safety of these new uses and quickly control those that pose an unreasonable risk to human health and the environment.

Recommendations to the EPA Administrator

We recognize the need to eliminate the use of chemicals that deplete stratospheric ozone. Like EPA, we believe that CFC and halon substitutes must be safe and not pose unreasonable risks to human health and the environment. To help ensure that EPA has access to unpublished health and safety studies on potential substitutes and is informed about intended new uses of existing chemicals as CFC and halon substitutes, we recommend that the EPA Administrator:

- Use his authority under TSCA section 8(d) to require chemical producers to submit for EPA review their unpublished health and safety studies on chemicals identified by EPA and industry as actual or likely potential substitutes for CFCs and halons. EPA should review this data as part of its assessment of the safety of these chemical substitutes to form a basis for requiring additional testing or controls, if needed.
- Use his authority under TSCA section 5(a)(2) to promulgate significant new use rules on alternative fluorocarbons and other chemicals listed in the TSCA inventory of existing chemicals (or subsequently added to it) that are substitutes, or likely potential substitutes, for CFCs and halons. This authority would require chemical producers to notify EPA before these chemicals are produced for significant new uses as CFC and halon substitutes and would enable EPA to review the safety of such uses and quickly control those that pose an unreasonable risk to human health and the environment.

EPA's Projects Strive for Reductions in Major Uses of CFCs and Halons

It may be several years before chemical substitutes become available to replace a significant portion of current CFC uses. And as yet, no suitable substitutes for halons have been identified. With this in mind, EPA is attempting to assist industry's search for other ways to adapt to the impending phasedown in the production of ozone-depleting chemicals. EPA's Office of Air and Radiation and its Office of Research and Development are funding nine projects at a cost of $441,100 that are designed to reduce the use of regulated CFCs and halons. In reviewing the projects' scopes of work and results, when available, we found that the projects are focused on major uses of CFCs and appear to be promising first steps in conserving the use of CFCs and halons. However, it is too soon to evaluate the overall success of the projects because they concern the initial steps in the investigation of conservation techniques.

EPA Has Authority to Conduct the Projects

EPA has broad authority to conduct research on technologies related to CFCs and halons. Section 153(b) of the Clean Air Act, as amended, authorizes the EPA Administrator to undertake research on methods to recover and recycle substances that deplete the ozone and methods of preventing their emission into the atmosphere. Likewise, article 9 of the Montreal Protocol states that parties to the protocol shall promote research on technologies for improving containment, recovery, recycling, or destruction of ozone-depleting chemicals directly or through competent international bodies. Table 3.1 lists the conservation projects on CFCs and halons that EPA has sponsored or is currently sponsoring as part of its research responsibilities. This chapter provides a status report on the objectives, goals, and scheduled outputs of these projects as of December 1988.

Table 3.1: EPA Projects on CFC and Halon Conservation

Project	Cost[a]	Starting date	Ending date
Evaluation of Refrigerant from Mobile Air Conditioners	$150,000	4–88	12–88
Cell Size in Rigid Foam Insulation	120,000	7–88	6–90
Vacuum Panels in Refrigerators	15,000	1–88	7–88
Refrigerant Blend of CFC and Dimethyl Ether	5,100	3–88	7–88
HCFC-22 as an Alternate Refrigerant	13,000	2–88	11–88
Military Specifications for CFC Solvent Use	30,000	1–88	9–88
Halon Research Panels	30,000	8–88	Mid–1989
Conference on Halons and the Environment	28,000	3–88	7–88
Discharge Testing of Halon 1301 Systems	50,000	10–87	11–88
Total	**$441,100**		

[a]Cost to EPA only. Some of the projects are co-funded by other organizations.

EPA's Project Selection Criteria

EPA told us that the projects selected address large sources of CFC and halon emissions that were identified by its research on ozone depletion and its discussions with industry and other federal agencies. Members of the Office of Air and Radiation were responsible for becoming familiar with particular CFC and halon applications, such as refrigeration or foam blowing. In so doing, they learned what hindered the reduction of CFC and halon use and what types of research were being considered by industry, academia, or other federal agencies. From this, they were able to put together workplans, including research ideas, that would attempt to remove or lessen some of the obstacles.

Project on Evaluation of Refrigerant From Mobile Air Conditioners

In 1985,[1] car and truck air conditioners (known as mobile air conditioners, or MACs) accounted for approximately 19 percent of the ozone-depletion potential of CFCs used in the United States. MACs are the single largest user of CFCs and are also a large source of emissions. The emissions occur at several points during the life of the MAC: when the MAC is first charged with CFC-12; while it is operating; while it is being serviced, repaired, or disposed of; or when it is damaged as a result of an accident.

Equipment has been developed that can be used to capture and purify contaminated CFCs that otherwise would be released during servicing.

[1]The data from 1985 is the most recent available. And, as noted in chapter 1, the percentages are weighted to reflect the varying ozone-depletion potential of CFCs.

Use of the equipment has not caught on, however, due to the high cost of recycling CFCs relative to their cost (less than $1 a pound in 1987) and the lack of assurances from auto manufacturers that their warranties will cover MACs using recycled CFCs. Typically, the practice has been for service mechanics to vent the CFC-12 into the atmosphere during repair and leak testing.

EPA is funding a project that is attempting to contribute to the eventual reduction of unnecessary MAC CFC venting by recovering and recycling used CFC coolant. The project is being conducted for EPA's Office of Research and Development by the Acurex Corporation in cooperation with an ad hoc industry group, which includes the Mobile Air Conditioning Society and the Motor Vehicle Manufacturers Association. If the automakers are to extend warranty coverage to MACs using recycled CFCs, they will need to be sure that recycled CFC coolant will perform within warranty specifications. They also need to be able to prescribe service procedures that will guide the recycling effort. For example, it would be impractical for MAC service technicians to conduct chemical analyses on all of the refrigerant removed from the system to see whether it is clean enough for reuse. The technician needs to be able to determine from readily available information (such as vehicle mileage or a particular system malfunction) whether or not the refrigerant can be put back into the system as is, or needs purifying.

Toward that end, Acurex is conducting a study of the deterioration of MAC refrigerant. Acurex will measure the deterioration of CFC-12 in a sample of MACs in four locations across the country. Different regions are being used to determine whether the degree of degradation depends in part upon climate. Likewise, different makes and ages of cars, as well as cars with different amounts of mileage, will be used to learn to what extent those factors influence refrigerant contamination.

The ad hoc industry group first met in January 1988 and discussed the sampling methodology. Acurex started work on the project in April 1988. The first step Acurex took was to sample a small number of MACs in order to become familiar with the project's testing procedures. According to EPA, Acurex then began delivering collection containers to the testing locations where samples of used refrigerant were taken. EPA said that 227 containers with used CFCs were returned to Acurex for analysis.

Acurex was scheduled to issue a final report in October 1988 describing the amount and nature of the deterioration and contamination that

takes place over various periods of time and the conditions that cause refrigerant contamination. We were told by EPA that this report will now be issued in December 1988. On the basis of the report, the ad hoc group will recommend a specific standard for recycled CFC-12 to the Motor Vehicle Manufacturers Association and individual automakers. This recommendation will assist the auto manufacturers to establish a corporate policy on a CFC fluid purity standard acceptable for in-warranty service and to develop suggested maintenance procedures incorporating CFC capture and reuse.

Project on Cell Size in Rigid Foam Insulation

Rigid foam insulation is produced by injecting CFCs into a liquid mass of plastic polymer material. The cells created in the blowing process within the plastic define its appearance and rigidity. The CFCs also remain in the cells as an insulating gas that reduces thermal conductivity from one side of the foam to the other. CFC-11 and -12 are commonly used in this process, in part because their low thermal conductivity gives the foam a high insulation value. CFCs also have an especially low rate of diffusion through the cell walls of some foams. EPA data show that in 1985 approximately 20 percent of all CFCs in the United States were used in this application.

In July 1988, EPA's Office of Research and Development awarded the Massachusetts Institute of Technology (MIT) a 2-year, $120,000 grant to investigate alternative blowing agents for foam insulation. The project will be conducted in parallel with related MIT research sponsored by the Department of Energy's (DOE) Building Systems Division. A committee with representatives from EPA, DOE, and industry will review the research objectives and preliminary progress of both MIT projects and also make suggestions on future research. The committee will also help to disseminate the results of both efforts to industry. And MIT will collaborate with the research laboratories of major firms in the industry.

MIT will attempt to demonstrate that small cell size increases the insulation capacity of foams and that small cells can be produced with environmentally acceptable blowing agents. The first phase is to evaluate the thermal conductivity of experimental small-cell foams that have been made in the United States, Europe, and Japan. The second phase will investigate production processes that can be used to achieve small cell size. Meanwhile, the project funded by DOE's Building Systems Division will conduct tests on other potential techniques for attaining high insulation values in foam, such as alterations in the foam material or

composition, that could make the cell walls more opaque or reflect more heat.

Refrigeration and Air Conditioning Projects

In 1985, residential and commercial refrigeration and air conditioning accounted for approximately 9 percent of the ozone-depletion potential of CFCs used in the United States. CFCs are used in two forms in these applications. CFC-12, in liquid form, is the refrigerant that flows through the cooling system. CFC-11 is used as a blowing agent for the foam wall panels that give a refrigerator cabinet its rigidity and insulating capacity. EPA is sponsoring three projects related to CFC use in refrigerators. Unlike the other EPA projects that are designed primarily to reduce the use of CFCs and halons, these projects have an added objective of attempting to increase the energy efficiency of the refrigerators. This objective arises from DOE regulations that will require increased energy efficiency from many household appliances in order to reduce the nation's energy consumption.

EPA and DOE Regulations

Manufacturers of appliances such as home refrigerators are faced with two regulations that could have an impact on the use of CFCs. The first is the impending EPA restriction on CFC production. The second is the National Appliance Energy Conservation Act of 1987, which set standards for the energy efficiency of a variety of appliances and is being implemented by DOE. The standards for refrigerators and freezers, two of the appliances covered by the act that are affected by the CFC regulations, must be attained for appliances manufactured on or after January 1, 1990. The act also requires that the Secretary of DOE publish a proposed rule by July 1, 1988, and a final rule by July 1, 1989, addressing the issue of whether there is a need to amend the efficiency standards for refrigerators and freezers set forth by the act. The proposed rule was published on December 2, 1988. It called for comments on several courses of possible action: leaving the standards as they are or increasing them to one of five new levels of energy efficiency. The comments are due by January 31, 1989.

The energy efficiency of refrigerators and freezers depends to a large extent upon the insulation materials used in the appliance walls. Appliance manufacturers claim that because of the high insulating value of CFC-blown rigid foam insulation, the new efficiency standards can best be met by increasing the use of CFC-blown foam. They point out that other means of insulating these appliances, such as vacuum panels or alternative blowing agents, are either unproven, more expensive, or less

energy efficient. The problem, as the manufacturers see it, is that EPA's CFC regulations and DOE's energy efficiency standards set up conflicting regulatory goals—one driving them to use less CFCs, the other to use more.

DOE held a public hearing on January 28, 1988, to allow interested parties to comment on the perceived conflict between the two agencies' regulations. EPA testified at the hearing that its regulations will not prohibit appliance manufacturers from meeting the energy efficiency standards. EPA cited two major reasons for this opinion. The first is that CFCs will still be available, though to a lesser degree, after the Montreal Protocol and EPA regulations go into effect in 1989. Appliance manufacturers will still be able to purchase CFCs, though probably at a higher price, in order to add insulating capability to their products. EPA also pointed out that any increased cost in rigid foam insulation or refrigerant due to higher CFC prices would be relatively small compared to the total cost of the appliance, suggesting that consumer prices will not be greatly affected.

The second reason that EPA gave for believing that the CFC regulations will not prohibit manufacturers from attaining DOE's energy standards is that there are several technological developments or chemical substitutes on the horizon that may at the same time increase appliance energy efficiency and decrease the need for controlled CFCs. These developments include (1) the use of vacuum panels instead of rigid foam insulation in refrigerator walls; (2) the use of chemicals with low or no ozone-depletion potential, such as dimethyl ether, HCFC-22, or HFC-134a, to dilute or replace the CFC-12 refrigerant; and (3) the use of CFC recovery and recycling equipment for used CFC-12 refrigerant. Described below are three EPA-sponsored research projects with the potential to address both the CFC and energy efficiency issues.

Vacuum Panels

The first project was a $15,000 interagency agreement with DOE's Solar Energy Research Institute in Golden, Colorado, to report on alternatives to CFC-blown foam insulation panels. EPA claims that recent research on vacuum insulation has shown that significant improvements in thermal insulation, and thus energy efficiency, are achievable in the near term through the use of vacuum panels instead of foam insulation. The Solar Energy Research Institute has worked on the development of vacuum panels for architectural applications and is now attempting to transfer the vacuum technology to appliances that require insulation.

The project had two major tasks. The first was to prepare for EPA a set of technical references that discuss the conceptual alternatives to CFC-blown insulating foams. According to an EPA official, the Institute satisfied this requirement by making a presentation of alternatives at a January 1988 CFC and halon conference in Washington, D.C., co-sponsored by EPA, the Conservation Foundation, and Environment Canada.

The second task was to publish an analytical description of the application of vacuum insulation to replace rigid CFC-blown insulating foams in appliances. According to the Institute project officer, the results of the analysis, done at DOE expense, were published in the Spring of 1988. The results indicate that the foam insulation in a typical refrigerator can be replaced with one layer of vacuum insulation with a small decrease in energy consumption. While the Institute estimated that the conversion would cost the manufacturer $45 net per unit, the usable space in the refrigerator would increase by nearly 6 cubic feet due to the comparative thinness (0.1 inches versus 1.6 inches of foam) of the vacuum panel. Two layers of vacuum panel instead of the foam would add $150 to the manufacturer's net cost of each unit but would reduce the energy requirement by 44 percent with little loss in usable space. The report indicated, however, that major technical problems still need to be resolved, including the durability and economical fabrication of the vacuum panels.

This concern was also reported to us by representatives of the Association of Home Appliance Manufacturers. One said that a Japanese firm marketed vacuum panel refrigerators for a short period before halting production because it could not develop a vacuum that held its seal. Another representative pointed out that refrigerators built today use very little steel and derive their rigidity from the foam insulation in the cabinet walls. Refrigerators with vacuum panels would need to be reinforced so that they could stand up properly. Despite these concerns, the Association supports EPA's involvement in this type of research.

Refrigerant Blend of CFC and Dimethyl Ether

The second refrigeration project involves an interagency agreement between EPA and DOE's Oakridge National Laboratories to test a European chemical producer's refrigerant made up of 86 percent CFC-12 and 14 percent dimethyl ether (DME). The producer claims that this mixture is compatible with current appliances, low in cost, and can increase the energy efficiency of the refrigerator by approximately 5 percent. EPA proposed to Oak Ridge's Energy Division that it test the mixture and report on the results. The 6-month project was budgeted at $7,600

($5,100 from EPA and $2,500 from DOE). Oak Ridge operated an 18-cubic foot residential refrigerator-freezer with the CFC/DME mixture at different control settings. From these test runs, Oak Ridge calculated and compared the energy consumption with baseline data with CFC-12 as the working fluid. A final letter to EPA with the results was submitted on July 14, 1988.

The letter indicated that the mixture yielded an energy savings of 5.8 percent when compared to use of CFC-12 alone. It was also indicated that 4.8 ounces of the CFC/DME mixture would perform as well as 6.0 ounces of CFC-12 alone. The mixture contained 4.1 ounces of CFC-12, 32 percent less than a normal charge.

The EPA project officer was very encouraged by the results of this effort. She reported that the technology had been presented at a refrigeration conference in July 1988 and that several refrigerator manufacturers approached the European developer of the mixture about obtaining samples.

We also spoke with representatives of the Air Conditioning and Refrigeration Institute and the Association of Home Appliance Manufacturers about the project. The Institute's representative would not say that the mixture was a sure thing, but endorsed EPA's support of this type of research. The Association representative said that the industry is concerned that DME might only be a short-term solution, but he agreed that the mixture should be examined.

HCFC-22 As an Alternate Refrigerant

A third EPA project, conducted at the University of Maine, concerns a modified refrigerator system. The developer of the modified system claims that it will reduce energy consumption by up to 25 percent and can operate using an alternative fluorocarbon, HCFC-22, as a substitute refrigerant for CFC-12. HCFC-22 has an ozone-depletion potential that is only 5 percent that of CFC-12. The initial purpose of the $13,000 project was to evaluate a working model of the prototype refrigerator using HCFC-22 as the coolant. In particular, the intent was to study the energy efficiency, temperature and humidity control, and overall reliability of this system relative to a traditional system cooled by CFC-12.

EPA reported to us that the contractor was unable to complete the modification of the refrigerator because he could not locate a compressor both compatible with HCFC-22 and small enough to fit into a home refrigerator. Instead, the contractor compared the relative performance of

CFC-12 and HCFC-22 in two refrigerators using a standard CFC-12 compressor. The EPA project officer claimed that this is useful information but conceded that it falls far short of what was expected. He said that it is possible that an HCFC-22 compressor could be designed and built (in fact, two European companies are developing HCFC-22 compressors) but that such an effort exceeded the scope of this project.

The representatives of the Air Conditioning and Refrigeration Institute and the Association of Home Appliance Manufacturers told us that HCFC-22 should be tested for refrigerator applications, though it is not a drop-in substitute and will require modifications to the refrigerator system. They supported EPA's involvement in such research.

Project on Military Specifications for CFC Solvent Use

CFC-113 is a solvent used to clean metals and electronic components such as circuit boards and semiconductors. The solvent may be used during the production process or as a maintenance measure after the product is manufactured. CFC-113, when mixed with other solvents, is considered to be one of the most effective cleaning agents available. In 1985, solvent cleaning of metal and electronic parts accounted for approximately 12 percent of the ozone-depletion potential of CFCs used in the United States. EPA has projected that, absent regulation, CFC-113 use will grow 1.5 times as fast as CFC-11 and CFC-12 between 1986 and 2000.[2]

The Department of Defense is a large purchaser of electronic equipment. The equipment that it purchases is often produced and maintained with CFC-113—a practice that is frequently called for in the Department's operational standards or product specifications. As a consequence, according to EPA, the standards and specifications used by the military have become de facto standards for civilian sectors of the economy. This is because electronic equipment producers set up their manufacturing process to meet the needs of their potentially largest customer (the military) and do not find it cost effective to set up separate procedures for other customers. It is also because nonmilitary consumers look to the military specifications as a yardstick for quality.

EPA maintains that CFC-113 does not need to be used as extensively as it is because other effective solvents are available, such as water-based cleaners, diluted mixtures of CFC-113 and alcohol or methanol, and a

[2]CFC-113 growth is seen not only in the United States, which accounts for nearly 40 percent of global use, but throughout the world. In the mid-1980s, the Japanese used .43 kilograms per capita, the United States .31 kilograms, and the European Economic Community .12 kilograms.

newly introduced solvent based on a family of chemicals known as terpenes. EPA also maintains that improvements in cleaning technology could be made that would allow the recycling of CFC-113 or reduce its emissions into the atmosphere during the cleaning process. EPA's claim that such choices are available is supported in varying degrees by firms in the chemicals and electronics industries (such as AT&T, ICI, Allied-Signal, Occidental Chemical Corporation, and Electrovert, Limited).

With these choices in mind, EPA believes that it may be possible for DOD to modify military specifications that unnecessarily stipulate the use of CFC-113. This in turn may cause the general industrial use of the chemical to decrease substantially. Accordingly, EPA awarded a $30,000 contract to ICF, Inc., to define and characterize military uses of CFCs and to identify how military product users or weapons systems designers have their CFC requirements translated into procurement and/or military specifications.

In June 1988, ICF, Inc., prepared for EPA a collection of documents related to use of CFC-113 as a solvent, including presentations made at working group meetings, minutes from those meetings, a DOD letter showing support in principle for CFC-113 reductions, and technical articles on CFC-113 use.

To assist with the effort to reduce the use of CFC-113, EPA has also formed a solvents workgroup comprised of representatives from the military and from the chemicals and electronics industries. The workgroup decided to undertake what is known as benchmark testing of CFC-113. The benchmark tests will document CFC-113's performance standards under different application circumstances. The objective behind documenting the standards is this: rather than having military specifications be "product specific" (requiring the use of CFC-113), the specifications would be "performance specific," allowing any solvent to be used that met defined performance standards. Solvents that perform as well or better than CFC-113 could then be used to satisfy some of the military's needs in place of the ozone-depleting chemical.

The testing plan has been drafted and reviewed by members of the workgroup. The DOD has agreed that CFC use should be examined and has reviewed and endorsed the benchmark testing effort. The tests are scheduled to be conducted by the Electronics Manufacturing Productivity Facility, with funding from the DOD and in-kind support from industry, by March 1989.

Halon Fire Extinguisher Projects

Halons 1211 and 1301 were developed for commercial use in the 1960s and 1970s as fire-fighting agents and explosion suppressants. Halons are the fire-fighting chemicals of choice in many situations because they are low in toxicity, which allows people to remain in halon-flooded rooms for a period of time without ill effect. And, unlike water and dry chemical extinguishers, halons do not damage valuable equipment and materials, such as computers, telephone switching centers, works of art, or rare books. However, halons contain bromine, which is considered a more serious threat to ozone than the chlorine found in CFCs. Since no substitutes having the halons' advantageous properties have been identified as yet, conservation efforts are particularly important. And, because a large percentage of halons are emitted during discharge testing, training, maintenance, or from leaks, industry representatives and EPA believe that significant conservation can be achieved.

Halon Research Panels

EPA estimates that in 1986 the U.S. military used approximately 6 percent of all halon 1301 and 34 percent of all halon 1211 in the United States, making it a major user of halon. The military uses halon extinguishers to protect ships, tactical vehicles, aircraft, computers, and other valuable property. However, most halon emissions do not involve actual fire fighting but occur during system testing and training exercises. For example, EPA data show that training accounted for 59 percent of 1986 halon 1211 emissions and that discharge testing accounted for 30 percent of halon 1301 emissions. In contrast, 21 percent of all halon emissions were due to fire fighting.

The U.S. Air Force has been searching for alternatives and control measures for about 3 years, including substitutes for training and testing applications. In August 1988, EPA and the Air Force entered into an interagency agreement regarding the development of alternatives to fire-fighting halons. The project has two parts, to be conducted by two separate panels. The first panel will include chemists, physicists, toxicologists, halon manufacturers, and environmentalists, who will review and document past and ongoing halon substitute and emissions reduction research conducted by the military and civilian sectors. The panel will also make recommendations for future research on halon alternatives.

The second panel will consist of halon users, research managers, and government officials. This panel's mission is to consider formally the recommendations of the first panel and, according to the EPA project

officer, determine whether the recommendations can be adopted by industry.

EPA is bearing the entire $30,000 cost of the project. EPA had hoped that the project would start in February 1988. The Air Force, however, did not issue approval for the project until August, which has delayed the formation of the panels. The initial plan was for the panels' final reports to be submitted by September 30, 1988. The first panel meeting was November 15-17, 1988, suggesting that the reports will not be completed until mid-1989.

Conference on Halons and the Environment

EPA supported an international conference on fire protection, halons and the environment, which was co-sponsored by the National Fire Protection Association and its European counterpart. The conference, held in Switzerland during June 1988, was the first international meeting on the ozone-depletion issue sponsored by the fire-fighting community. The main purpose of the meeting was to discuss the current status of technologies available for reducing the use of halons, such as substitute chemicals, alternative production and testing methods, and alternative fire protection strategies.

EPA awarded a $28,000 contract to ICF, Inc., to provide organizational and promotional support for the conference. The work was subcontracted to the National Fire Protection Association. It included selecting speakers from the United States and Canada, mailing conference announcements to the appropriate organizations, and preparing a conference summary for EPA by July 30, 1988.

EPA's representative to the conference told us that the discussion focused mainly on current uses of halons and methods to reduce emissions. He noted that there were encouraging discussions about considering an international agreement to use halons only to fight fires (not for testing or training) and to certify technicians who work with halons to ensure that they handle them properly. He also said that the conferees generally agreed that development of halon substitutes is possible.

We also spoke with a manufacturer of halon systems and the president of the Halon Research Institute. Both said that the conference was helpful in disseminating information about alternatives to halon use and methods for reducing emissions. The manufacturer commented that the Europeans appear to be more advanced in fire detection technology,

which decreases the likelihood that halon systems will discharge unnecessarily, while the North Americans are more experienced with alternative discharge testing substances. He said that the conference provided an opportunity to exchange this information. The Institute president said that the conference indicated to the fire-fighting community that chemical producers are moving ahead with the development of chemical substitutes. No details could be revealed for proprietary reasons.

The two halon industry representatives also noted that the conference participants discussed industry guidelines that could help reduce halon emissions. A proposal has been made to the National Fire Protection Association that labels be placed on halon canisters recommending that they be returned to the manufacturer after use so that any remaining halon can be captured. The labels would also suggest that halon be used only when other fire extinguishers are inappropriate and not be used for discharge testing. We were also told that, currently, certification of halon system technicians is limited and that certification is receiving greater attention due to ozone depletion and the pending regulations.

Discharge Testing for Halon 1301 Systems

As described above, a large portion of the halon emissions that contribute to ozone depletion result from discharges during tests of the fire-fighting system. EPA and others claim that the tests can be conducted in ways that will reduce emissions. Toward that end, EPA awarded a $50,000 contract to the National Fire Protection Association's Research Foundation to conduct research that will provide a technical basis for evaluating sound ways of reducing unwanted discharges of halons. The objectives of the project were to (1) establish a starting point for research into alternative practices; (2) determine the state of knowledge regarding halon system performance, performance test methods, alternative test methods, and alternative test agents; and (3) evaluate the most promising methods of reducing unwanted discharges without reducing fire safety. The project did not include the development of alternative technologies or testing agents.

An initial presentation of the project results was made at the January conference on CFC and halon substitutes co-sponsored by EPA, the Conservation Foundation, and Environment Canada. A presentation of the project findings was also made at the halon conference in Switzerland described above. A final report is scheduled to be presented to EPA by the end of 1988. We reviewed a draft of the report. It points out that

there are several objectives of discharge testing that should be preserved in any alternative testing methods in order to ensure the reliability of the fire protection system. The most dominant problem in system performance is the inability to maintain the halon 1301 design concentrations due to leakage of the halon out of the area to be protected. Discharge testing helps indicate the presence of leaks. The draft stated that it would not be appropriate to eliminate discharge testing at this time but noted that alternative methods to meet this test's performance objectives are being researched and appear to be within reach. Accordingly, the draft proposed a near-term research agenda that would focus on alternative testing agents and diagnostic techniques that could reduce the need for full discharge testing with halon 1301.

Conclusions

The projects sponsored by EPA are appropriately focused on the major uses of ozone-depleting chemicals. The Agency has identified areas in which potential CFC and halon reductions in use can be made and has gathered the support of the appropriate federal agencies and industry groups in the attempt to attain those reductions.

At this time, it is difficult to assess the effect that these projects may have on reducing the use of ozone-depleting chemicals. Even if the projects meet their goals, they represent only the first stages in a lengthy development process aimed at achieving significant reductions in CFC and halon use and emissions over the coming years. Society's shift away from the use of ozone-depleting chemicals will take time to accomplish. Exactly how much time is difficult to determine, since that depends mainly on the ingenuity of chemical producers and industry in finding substitutes and alternatives to what are very useful, but ultimately environmentally harmful, chemicals.

Key Provisions of the Montreal Protocol

The Montreal Protocol, signed in late 1987, was ratified internationally in late 1988 and went into force on January 1, 1989. The purpose of the Montreal Protocol is to reduce the depletion of stratospheric ozone by limiting the participating countries' total production and consumption of certain ozone-depleting chemicals according to a specified schedule. Two groups of chemicals are affected:

Group I - CFCs	Group II - Halons
CFC-11	Halon 1211
CFC-12	Halon 1301
CFC-113	Halon 2402
CFC-114	
CFC-115	

Halons and CFCs are treated separately under the protocol. Halons are currently produced in far smaller quantities than CFCs, and less is known about the halons' worldwide production and use. However, halons are substantially more potent ozone-depleting chemicals. Within each group of substances, each chemical is assigned an ozone-depletion weight, a measure of its relative ability to destroy ozone molecules in the atmosphere. These weights are:

Chemical compound	Depletion weight
CFC-11	1.0
CFC-12	1.0
CFC-113	0.8
CFC-114	1.0
CFC-115	0.6
Halon 1211	3.0
Halon 1301	10.0
Halon 2402	To be determined

Under the protocol, future production of the controlled chemicals is tied to 1986 levels. Production is defined as the amount of controlled chemicals produced minus the amount destroyed by approved technologies. Consumption is defined as production of controlled chemicals plus imports minus exports.

The protocol calls for a freeze in production and consumption levels of Group I chemicals (the CFCs) at 1986 levels beginning July 1, 1989, 6 months after the protocol enters into force. Reductions of 20 percent

from 1986 levels of these same chemicals would be required by July 1, 1993. Reductions of 50 percent would be required by July 1, 1998.

Production and consumption of the Group II chemicals will be frozen at 1986 levels in 1992, 3 years after the protocol enters into force.

Production may be shifted from a chemical in one group to another chemical in the same group, provided that the total ozone-depletion potential is not increased. For example, a producer could manufacture 100 kilograms of Halon 1211 instead of 30 kilograms of Halon 1301, or 80 kilograms of CFC-11 instead of 100 kilograms of CFC-113. Trades between Groups I and II are not permitted.

Trade Provisions

The protocol contains provisions that provide incentives for countries to join the agreement and other provisions that minimize potential adverse economic effects on signatory countries. For instance, by January 1, 1990 (1 year after entry into force), each party must ban imports of bulk controlled substances from nations that are not party to the protocol. And there is a provision for participating developing countries now using less than 0.3 kilograms per capita of the controlled chemicals to increase consumption for 10 years, or until they reach 0.3 kilograms per capita, before being required to abide by the restrictions of the protocol. Before 1998, producing participants would be allowed to exceed the ceiling imposed by the protocol by up to 10 percent of their 1986 levels, but only for "industrial rationalization" or export to qualifying developing countries. After 1998, levels can be exceeded by up to 15 percent, unless otherwise decided by the participants.

Industrial rationalization is the transfer of all or a portion of the calculated level of production of one party to another for the purpose of achieving economic efficiencies or responding to anticipated shortfalls in supply as a result of plant closure.

A ban or restriction on the import of products containing controlled substances from nonparties is scheduled to go into effect by approximately January 1, 1993, based on a product list to be developed by the parties. By January 1, 1994, consideration will be given to restricting imports from nonparties of products produced with controlled substances (e.g., electronic components that are cleaned with CFC-113). The protocol also discourages the parties from exporting to nonparties technology for producing or using controlled substances.

Periodic Reassessments

Because of scientific uncertainties, reassessments of the protocol provisions will be made on a regular basis. The first reassessment report was scheduled to be issued in 1990, although, as mentioned in chapter 1, it is now tentatively to be issued in 1989. The reassessment will examine atmospheric sciences, the effects of ozone depletion, technical controls options, and the coverage and stringency of the protocol.

Other Provisions

The protocol urges bilateral and multilateral cooperation among the parties, as well as cooperation through international organizations on research, exchange of information, and development of public awareness. There will be an emphasis on technologies for reducing emissions of controlled substances as well as on alternative chemicals and chemical products.

The protocol establishes requirements for data reporting, calling for the United Nations Environment Programme to convene a meeting of government experts to recommend to the parties measures for coordinating data on production, imports, and exports.

Summary of EPA Memorandums Leading to the November 2, 1988, Assessment Approach

1. OAR Memo to OTS (December 8, 1987): Cited "essential" need for cooperation within EPA to avoid creating new health or environmental problems while reducing use of CFCs and halons. Suggested three areas for cooperation: (1) providing consistent answers relating to toxicity questions raised by industry and efficient reviews of new chemical substitutes; (2) coordinating the regulation of CFCs and other chlorinated solvents, since the chemicals are interchangeable in some applications; and (3) encouraging the use of aqueous cleaners in certain applications that would reduce the use of both CFCs and chlorinated solvents. Suggested that issues be coordinated through a workshop or informal meeting.

2. OTS Memo to OAR (April 14, 1988): Reply to OAR 12-8-87 memo. Suggested establishing comprehensive and uniform EPA guidance regarding testing objectives and methods for CFCs, chlorinated compounds, and their substitutes. Proposed that this guidance be developed by a standing, interoffice Chlorinated Compound Testing Committee. Suggested holding a meeting to establish procedures for forwarding information to OAR on new chemicals that could potentially substitute for CFCs.

3. OAR Memo to OTS (May 25, 1988): Reply to OTS 4-14-88 memo. Proposed meeting with OTS to (1) determine which potential substitutes identified so far would be subject to a new chemical review and which would not and (2) explore TSCA authorities to ensure that toxicity testing on substitutes is done properly, particularly in regard to the chemical producers' international joint testing program (PAFT). Disagreed with OTS' proposal to set up interoffice Chlorinated Compound Testing Committee and proposed instead to pursue the issue in two subsequent OAR/OTS meetings.

4. Minutes of July 6, 1988, OAR/OTS Meeting: OTS stressed the need for EPA to become apprised of the identity of chemicals used to replace CFCs and to understand the nature and degree of risks posed by these chemicals. Agreement reached on procedure for a coordinated review of new chemical substitutes. Agreement reached to develop a proposal for a CFC Substitute Committee.

5. Minutes of July 12, 1988, Special Meeting of OTS Testing Priority Committee: OAR briefed the committee on CFC issue. Discussed need for an agreement between EPA and PAFT on reviewing testing protocols and results. Discussed need to obtain industry toxicity studies of HCFC-22 and -142b, currently in commercial use. Agreed that the Testing Priority Committee would be an appropriate forum for dealing with the substitute safety issue. Agreed to develop a list of issues and questions that

need to be resolved in order to demonstrate that a substitute review process is in place and to ensure that EPA satisfactorily identifies and evaluates CFC substitutes.

6. OTS Internal Memo (July 19, 1988): Laid out issues needing resolution, including the composition of the CFC substitute review committee, its mission, procedures, scope, and time frames.

7. OTS Internal Memo (August 17, 1988): Cited need to resolve issues regarding EPA's responsibilities for the safety of CFC substitutes. Set forth options for identifying substitutes, obtaining health and safety studies from chemical producers, and assessing risks posed by substitutes and controlling their use, if necessary. Laid out pros and cons of using various TSCA authorities and/or voluntary agreements with industry to pursue these issues.

8. OTS Internal Memo (September 9, 1988): Raised issue of whether CFC substitutes should be considered on a case-by-case basis or whether a policy context should be developed within which they would all be consistently considered (e.g., should there be uniform testing, review, and control requirements for both new and existing chemical substitutes?).

9. OAR Memo to OTS (draft assessment plan - September 12, 1988): Broadly outlined a process for coordinating EPA review of toxicity issues related to CFC and halon substitutes through an ad hoc interoffice subcommittee of OTS' Testing Priority Committee. Subcommittee would be established by OTS, pending management approval. Procedural details left to be defined at a later date. Subcommittee to prepare a report summarizing existing toxicity and exposure data on substitutes. This report would be reviewed by the directors of OTS and OAR, who would determine what, if any, further actions need to be taken. Subcommittee would also develop procedure to review test plans of PAFT. No time frames specified for startup of subcommittee or any of its activities.

10. OTS Memo to OAR (draft assessment plan - September 23, 1988): Proposed that the general goal of the assessment process be "to ensure that any substitutes adopted present no unreasonable risks, and present the least risk, considering both toxicity and ozone depletion, of known likely substitutes." It also stressed the need to ensure that the toxicity testing be done "correctly" and "uniformly" for both new and existing chemicals. As in the final November 2, 1988, plan, this draft included an EPA review of existing toxicological data on the substitutes, the identification of testing needs, and voluntary cooperation of industry in providing

EPA with needed assessment information, though it proposed that OAR and OTS staff develop an options analysis on the possible use of SNURs for some or all of the likely existing chemical substitutes.

11. OAR Memo to OTS (November 2, 1988): Set forth the final version of EPA's approach for assessing the safety of CFC and halon chemical substitutes (discussed in chapter 2).

Major Contributors to This Report

Resources, Community, and Economic Development Division Washington, D.C.

Hugh J. Wessinger, Senior Associate Director, (202) 275-5489
Richard L. Hembra, Associate Director
Patricia D. Moore, Assistant Director
John P. Finedore, Evaluator-in-Charge
Ross E. Campbell, Evaluator

*U.S. G.P.O. 1989-241-164:80390

Requests for copies of GAO reports should be sent to:

U.S. General Accounting Office
Post Office Box 6015
Gaithersburg, Maryland 20877

Telephone 202-275-6241

The first five copies of each report are free. Additional copies are $2.00 each.

There is a 25% discount on orders for 100 or more copies mailed to a single address.

Orders must be prepaid by cash or by check or money order made out to the Superintendent of Documents.